Investigating the Feasibility of Small-Scale Broiler Farming

by
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Abstract

Small-scale farmers have the opportunity to gain access to markets through a contract farming arrangement. The key question is whether it is financially feasible for a small-scale farmer to enter into a contract.

The objectives of this study were to develop a model that could be used to determine the financial feasibility of small-scale contract broiler farming in an intensive production system, compare three different genotypes namely: Cobb500 males X Hybro G females, Ross 308 males X Potchefstroom Koekoek females (crossbred) and the purebred Potchefstroom Koekoek, and evaluate current small-scale farmers' broiler production by means of a case study. Financial performance indicators such as the net present value, cash flow and profit and loss statements were used to analyze the feasibility of all the scenarios.

The model was built in Microsoft Excel. Five hundred, 1500 and 2500 birds/cycle scale of production were analyzed. Results revealed that based on the capital costs used, a 500 birds/cycle scale of production was uneconomical and that a farmer would have to receive R25.01/kg broiler meat in order to break even. The 1500 scale of production showed much better results. A farmer could break even at R17.51/kg meat. The capital investment cost of the 2500 scale of production was so high that the farmer would have had to sell his broiler meat for R18.54/kg.

Performance traits of genotypes were collected through an experiment and data was statistically analyzed using 'Statistica 9'. Results showed that there were significant differences between the cumulative feed intake, feed conversion ratios and the European production efficiency ratio of the different genotypes. No significant difference was found in the liveability of the genotypes.

Data on performance traits was used as input into the model so that the economic feasibility of the genotypes could be compared. Results showed that a purebred Potchefstroom Koekoek genotype was not suitable for an intensive production system and that the crossbreed did not perform as well as the broiler breed, but that it would be worthwhile investigating the performance traits of the cross breed under less optimal conditions or in a free-range system. The lower capital costs necessary for a free-range system, together with the high premium paid for free-range broiler meat, may give admirable results in the economic feasibility of a small-scale broiler farm.

Opsomming

Kleinboere het die geleentheid om deur kontrak boerdery toegang tot markte te verkry. Die vraag is egter of dit finansieël haalbaar is vir 'n kleinboer om kontraktueel verbind te word? Die doelwitte van die studie was om: ‘n model te ontwikkel wat gebruik kan word om die finansiële lewensvatbaarheid van' n klein-skaalse braaikuikenboer te bepaal onder 'n intensiewe produksiestelsel; verskillende genotipes naamlik: Cobb500 hane X Hybro G henne, Ross 308 hane X Potchefstroom Koekoek henne (kruising) en die suiwer Potchefstroom Koekoek te evalueer en die die huidige klein-skaal boer se braaikuikenproduksie deur middel van 'n gevallestudie te evalueer. Finansiële prestasie aanwysers soos die netto huidige waarde, kontantvloei, asook wins en verlies state was gebruik om die haalbaarheid van die verskeie gevalle te analiseer.

Die model is op Microsoft Excel gebou. ‘n Produksie skaal van 500, 1500 en 2500 kuikens/siklus is ontleed. Resultate het getoon dat, gebaseer op die kapitale koste wat gebruik is, 'n produksie skaal van 500 kuikens/siklus onekonomies is en dat ’n boer R25.01/kg sal moet ontvang om gelyk te breek. Die produksie skaal van 1500 kuikens/siklus het beter resultate getoon. 'n Boer kan gelyk breek teen R17.51/kg vleis. Die kapitale beleggingskoste van die produksie skaal van 2500 kuikens/siklus was so hoog dat die boer R18.54/kg sou moes ontvang het om gelyk te breek.

Prestasie van genotipes is ingesamel deur middel van 'n eksperiment en data is statisties ontleed met behulp van Statistica 9. Resultate het getoon dat daar hoogs beduidende verskille tussen die kumulatiewe voerinname, voeromsetsverhoudings en Europese produksie effektiwiteits verhouding van die verskillende genotipes is. Geen beduidende verskil is gevind in die leefbaarheid van die genotipes nie.

Inligting oor die prestasie eienskappe is gebruik as insette tot die model sodat die ekonomiese haalbaarheid van die genotipes vergelyk kon word. Resultate het getoon dat 'n suiwer Potchefstroom Koekoek genotipe nie geskik is vir 'n intensiewe produksie stelsel nie en dat die kruising nie so goed soos die braaikuiken gevaar het nie, maar dat dit die moeite werd sal wees om ondersoek in te stel na die produksie potensiaal van die kruis kuiken in minder optimale toestande, soos ‘n vryloop stelsel. Die laer kapitale koste en die hoë premie wat betaal word vir vryloop braaikuikenvleis mag geloofwaardige resultate op die ekonomiese haalbaarheid van 'n kleinskaalse braaikuikenboer toon.

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Acronyms

ARC	Agricultural Research Council
CASP	Comprehensive Agricultural Support Program
CF	Contract Farming
DPFO	Developing Poultry Farmers Organisation
EPEF	European Production Efficiency Factor
FAO	Food and Agriculture Organization of the United Nations
FCR	Food Conversion Ratio
HC	Hybro hens X Cobb500 roosters
KK	Potchefstroom Koekoek hens X Potchefstroom Koekoek roosters
KR	Potchefstroom Koekoek hens X Ross roosters
NCF	Net Cash Flow
NPV	Net Present Value
SAPA	South African Poultry Association
VBA	Visual Basic Programming

1 Introduction

The small-scale farming sector in South Africa has the potential to mitigate the problems of rural poverty, unemployment and food insecurity. Yet, attempts by government to promote and achieve sustainable small-scale farming have been disappointing. As a result, small-scale farmers are still often viewed as non-productive, non-commercial, subsistence farmers (Kirsten & J, 1998).

The examination of current and past efforts can lead to an understanding of factors involved, after which an approach can be recommended that may tangibly improve performance in the developing small-scale farming sector. After reviewing the evidence with respect to past and current efforts to support small-scale farmers in South Africa, a report published by the government reached the following conclusions (Aliber & Hall, 2010):

1. "Past and existing attempts by government to support small-scale farmers in South Africa have in general been costly and ineffective, in large part because they have been top-down and inappropriate in both design and implementation" (Aliber & Hall, 2010). Problematic approaches included prescribing to farmers what to produce, what technologies to use and at what scale. Government proposed the use of strategic and catalytic interventions that combine national regulation through the value chain to enable market access on equitable terms for small farmers (Aliber & Hall, 2010).
2. "The single most significant 'asset' available for developing small-scale farmers is small-scale farmers themselves" (Aliber & Hall, 2010). Empowerment initiatives should create conditions that allow farmers to realise their potential. Support should also be given to small-scale farmers who have previously been involved with agriculture (Aliber & Hall, 2010).
3. "Conditions in South Africa are not fully conductive to small-scale farmer development, but neither are they entirely hostile" (Aliber & Hall, 2010). Key constraints include the structure of the economy and the shortage of water. The dualistic nature of the economy has major disadvantages to small farmers. They find it difficult to gain access to markets as they have to compete with large established companies. Water shortages limit the opportunities for development and climate change may exacerbate this (Aliber & Hall, 2010).

Aliber & Hall (2010) goes on to say that the present dualistic nature of the agriculture sector is in need of a successful "missing middle" division. One proposed approach by government is to modify/align existing programmes so that they fortify the emerging approach, especially the Comprehensive Agricultural Support Program (CASP) and land redistribution. The focus is to modify the CASP so that it favours off-farm facilities that are of common benefit to a larger number of farmers, as opposed to the current emphasis on on-farm infrastructure, which benefits very few people.

It is proposed that an institutional arrangement, namely contract farming, be used in this study. The institutional arrangement is also referred to as an "out-grower scheme". The idea of an out-grower scheme is that farmers have a contract with an agro-processor to whom they are obliged to sell their output. In return, the agro-processor provides certain services such as extension, transport, inputs and sometimes even land preparation. The advantage for the agro-processor is that throughput is consistent and known, and for the farmers the advantage is that they are ensured of a market for their produce. The farmers gain market access as well as services from the agro-processor, which would otherwise not have been available to them.

1.1 Rationale

Many different forms of out-grower schemes exist. The literature on contract farming is briefly reviewed: Porter & Phillips-Howard (1997) reviewed the experience of contract farming (CF) in Africa in the early 1990s. They concluded that farmers were generally better off as a result of their participation in CF, in spite of a number of social problems that arose in the communities. Birthal & Joshi (2005) state that the institutional arrangement offered by CF could enable farmers to access markets. According to Glover (1984), contract farming holds considerable potential for rural development. It can facilitate the transfer of technology and the integration of small-scale farmers into the national economy. More researchers have similar viewpoints: Weatherspoon *et al.* (2001) states that CF offers a mechanism that ensures self-sustained development. Simmons *et al.* (2005) examine contract growers of poultry, maize seed and rice seed in Indonesia. They conclude that the contracts increase income and welfare, reducing absolute poverty.

CF is used in the state of Sarawak, Malaysia, as part of an affirmative action programme (Morrison *et al*., 2006). The state of Sarawak recognizes that CF is part of a broader national goal to eradicate poverty and thereby contributes to food security.

1.2 Aim

The aim of this study was to determine whether contract farming is a feasible arrangement for small-scale broiler farmers.

The choice to work on small-scale broiler agriculture in South Africa was influenced by the major role the agricultural sector plays in poverty alleviation and ensuring food security in Africa. The poultry industry is the fastest growing agricultural sector in the world, with a per capita consumption of 31.8 kg per person per annum, an increase of 1.2 % on a yearly basis (SAPA, 2010).

1.3 Objectives

The objective of the study was to develop a model that could be used to determine small-scale broiler farmers' economic outcomes if farmers were to produce under contract.

The model focused on economic indicators and included tools that could be used to compare current and proposed practices. The results obtained should show the benefits or losses a small-scale broiler farmer would experience when farming under contract.

Another aim was to evaluate the feasibility of a different genotype from that normally grown commercially. The broiler which was evaluated was a cross between an indigenous Potchefstroom Koekoek and a commercial Ross 308. Performance parameters were determined for this crossbred broiler and entered into the economic model. Performance traits were compared biologically and economically to a commercial broiler genotype and to an indigenous Potchefstroom Koekoek. It was envisaged that the advantages of a crossbreed chicken could include:

- Reduced mortalities due to higher disease resistance in the indigenous breed.
- Better overall performance in less than optimal conditions or in a free-range system.

The necessary information was gathered by means of unstructured interviews and participatory approaches. Structured interviews were held with strategic and business experts in order to validate different CF organizational structures. Broiler production experts were asked about production parameters associated with producing broilers and about their view on the proposed CF approach. Experts in the field of small-scale farming contributed in terms of social and cultural obstacles that were known to impede the small-scale farming industry.

Furthermore, unstructured interviews were held with emerging farmers in order to determine their specific needs and goals. The farmers are all part of the Developing Farmers Poultry Association and interviews were conducted at the Avi-Conference held by the South African Poultry Association (SAPA) in May 2010.

1.4 Outline

The study follows the following structure: Chapter 2 deals with the context of the research, the justification of the approach and general issues underlying the modelling framework. This chapter also reviews the poultry industry, specifically the broiler industry, and small-scale farming in South Africa is reviewed in order to gain knowledge of past and current practices.

Chapter 3 reviews contract farming. The chapter presents a detailed discussion on contract farming; key preconditions, advantages and disadvantages.

Chapter 4 explores the scope, possibilities and limitations of different approaches that have been developed under the heading of 'bio-economic modelling'. Key features of bio-economic models are also reviewed.

Chapter 5 explains the methodological details of the modelling framework. The model is described and documented and input/output parameters are explained.

Chapter 6 explains the data collection methods and data analysis methods.

Chapter 7 presents the results of different scenarios tested on the model. Firstly, results are presented based on commercial broiler production standards and remuneration. Next, the model is used to compare the economic outcomes if three different genotypes are used. Finally, results are presented on cash flows of a farmer who produces chickens in Hopefield, Western Cape.

Chapter 8 presents the conclusions of the study and aims to answer the research questions developed in the first chapter.

Literature Review

2 Poultry Industry

The poultry industry in South Africa is made up mainly of two sectors: egg production and broiler production. Broilers are grown for slaughtering purposes and are defined as chickens hatched from the eggs of breeders. The term "breeders" is used to refer to the parent chickens that produce fertile eggs, which are hatched to produce broiler chicks. Layers, on the other hand, are chickens with exceptional egg production traits which produce eggs that are sold directly as table eggs (Coetzee *et al*., 2007).

2.1 Background

The South African poultry industry, with a gross value of more than R23 billion, is the country's largest individual agricultural industry which contributes more than 17 percent of agriculture's gross domestic product (Esterhuizen, 2010). On national scale, commercial broiler producers and contract growers produce the majority of broiler meat in South Africa, accounting for approximately 379 and 196 industry suppliers respectively (Coetzee *et al*., 2007). According to Du Toit (2005), both the vertically integrated poultry businesses and the contract farmers jointly represent 81% of total sales in South Africa.

South Africa's broiler industry is dominated by two large producers, namely Rainbow and Astral. Rainbow produces on average 4.4 million broilers per week and Astral on average, 3.8 million broilers per week (Esterhuizen, 2010). Country Bird is the third largest producer in South Africa, producing on average 1.3 millions broilers per week in South Africa (Esterhuizen, 2010). Figure 1 shows the market share of broiler producers in South Africa.

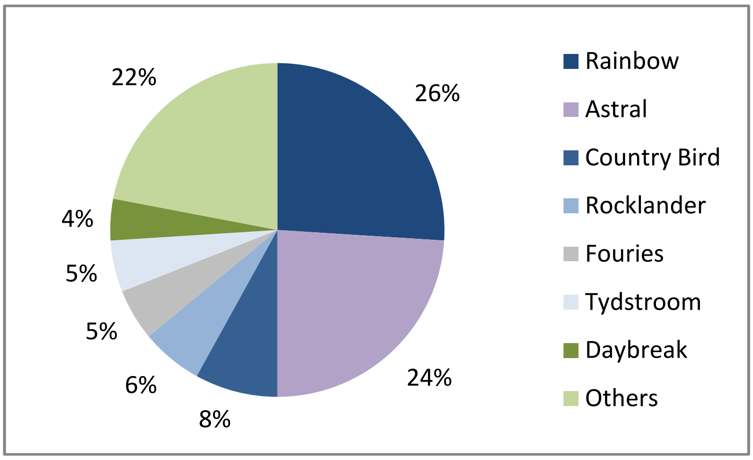

Figure 1 Major broiler producers in South Africa (Esterhuizen, 2010)

Figure 2 shows that on average 18 204 699 broilers were slaughtered per week in March 2010. This was approximately 300 000 broilers more than what was slaughtered in March 2009. The broiler production level forecast for October 2010 was 18 746 000 which is 1 323 200 broilers (+7.6%) higher than the October 2009 figure (SAPA, 2010).

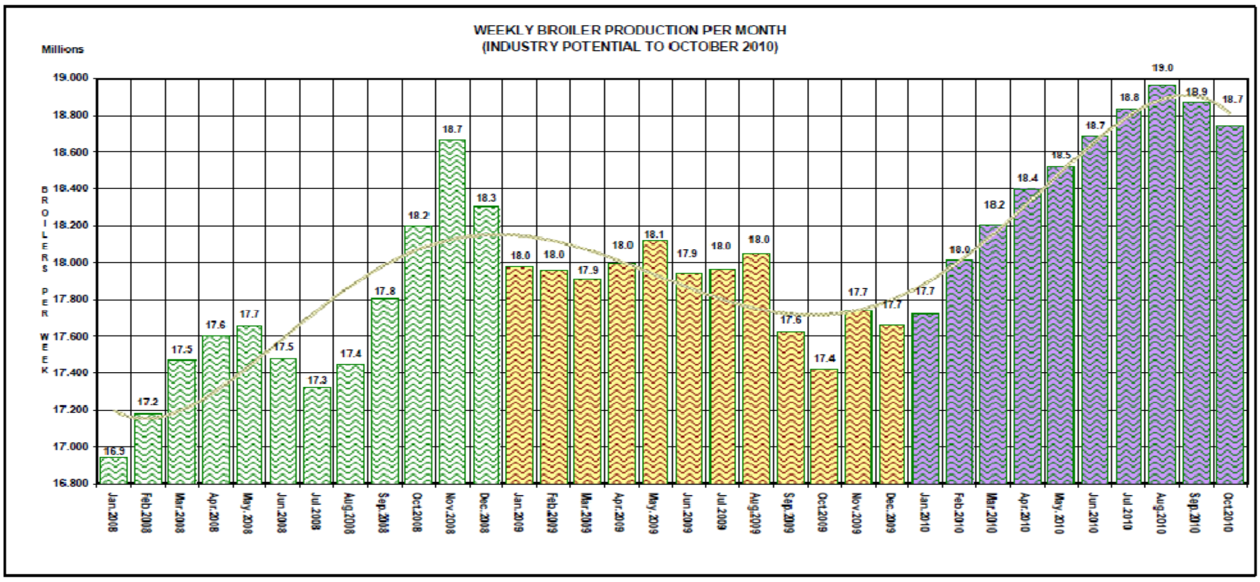

Figure 2 Broiler production forecast from April 2010 – October 2010 Source: (SAPA, 2010)

The per capita trends for meat produced in South Africa are illustrated in Table 1. Compared to beef, mutton and pork, broiler meat is by far the most popular form of meat in South Africa.

Table 1 Per capita consumption (kg) of meat in South Africa Source: (Department of Agriculture, 2009)

Years	Beef	Broiler Meat	Pork	Mutton/lamb
1996	14.6	17.8	3.3	3.5
2001	21.3	18.9	2.6	3.5
2005	15.5	23.1	3.9	3.2
2006	17.4	25.8	4.1	3.4
2007	18.2	29.6	4.4	3.9
2008	16.4	30.0	4.2	3.7
2009	16.7	30.8	4.1	3.7
2010(estimate)	17.0	31.7	4.2	3.8

Another important supply is that of imported broiler meat. Figure 3 clearly shows that the majority of broiler meat imports are from Brazil. According to SAPA (2010) and Coetzee *et al.* (2007), imports are largely attributed to exchange rate movements. Other factors contributing to Brazil's competitive edge include: Economies of scale, favourable climatic conditions and Brazilian government support (Coetzee *et al*., 2007).

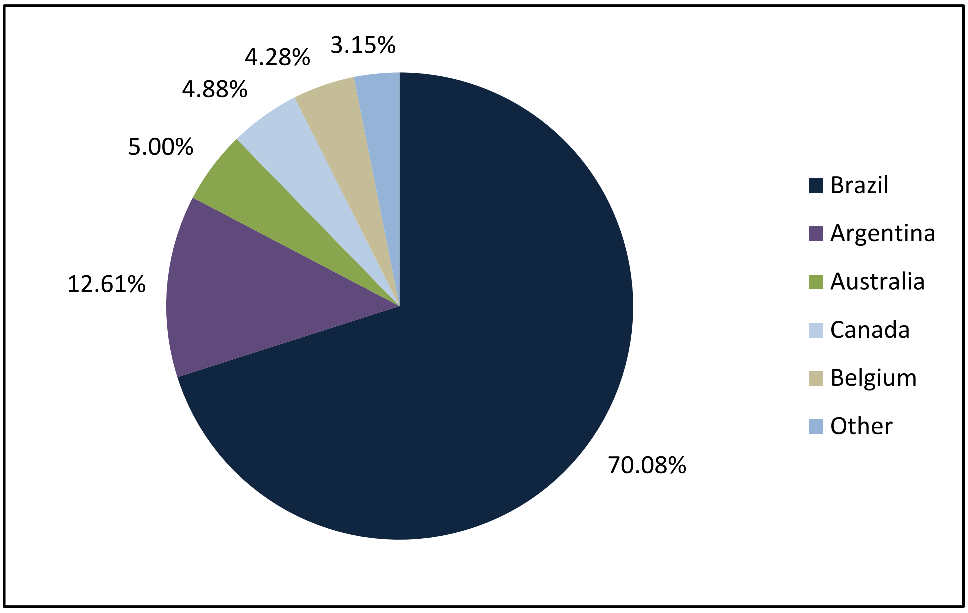

Figure 3 Origin of poultry imports into South Africa for the second quarter 2009 (SAPA, 2010)

2.2 Small-Scale Broiler Farming

With the increasing commercialization of agriculture and food systems worldwide, the large agribusinesses are dominating the industry whilst the influence of farmers is declining (Sautier *et al*., 2006; Reardon & Batter, 2000). The changes in the agricultural industry have also influenced the need for higher levels of managed co-ordination. This has resulted in the introduction of different forms of vertical integration and alliances, which have become a dominant feature of agricultural supply chains (Kirsten & Sartorius, 2002).

According to Bienabe *et al*. (2004) small-scale farmers find it difficult to make the transition to a more commercial food system because they struggle to meet the standards set by food processors and are also constrained by limited government support due to policy reforms, market liberalisation, and fiscal and governance problems. Furthermore, small-scale farmers across the world face a number of other challenges ranging from political and socio-economic challenges, such as poverty, global food market dynamic to biophysical challenges such as climatic variability, land degradation and disease outbreaks (De Haan *et al*., 2001).

The Development Poultry Farmers Organisation (DPFO) and the South African Poultry Association (SAPA) have proposed that contract farming be an entry point for empowering small-scale broiler farmers (DPFO & SAPA, 2005). According to Bonnen & Schweikhardt (1998), once contract farming arrangements are modified to suit country-specific conditions, the arrangement can be used to overcome transaction cost barriers, technology, completion and low prices. Contract farming is reviewed in more depth in Chapter 3.

2.2.1 Characterization of Small-Scale Broiler Systems

This section begins with a broad overview of broiler production systems. The Food and Agriculture Organization of the United Nations (FAO) has classified poultry production systems in four categories or sectors based on the level of integration of operations, the marketing system and the level of biosecurity (FAO, 2004).

Sector 1: Industrial Integrated System

Sector 2: Industrial Sector

Sector 3: Semi Commercial Sector

Sector 4: Village/Backyard Sector

The Industrial Integrated System (Sector 1) has high levels of biosecurity. Such systems in the broiler industry in South Africa include, among others: Rainbow, Astral, County Fair and Tydstroom. All operations are integrated. In such a system the integrator, such as Rainbow, usually owns the feed mill, broiler breeders, hatchery, broiler farms and may also have contract growers.

Sector 2 refers to a commercial poultry production system with moderate to high biosecurity. The birds are usually marketed commercially.

The sector 3 semi-commercial poultry production system has low to minimal biosecurity. Birds are sold commercially, as well as to local markets.

Sector 4 refers to village-level production systems where households raise a few birds, usually for their own consumption or for local markets. These systems have minimal levels of biosecurity. These systems are also known as backyard poultry production and family production systems. The farmers are often known as subsistence farmers.

2.2.2 Critical Operations Management for Broiler Producers

An overview of key points that must be addressed in broiler production is presented in this section. Main topics covered include: general management; housing and environment; hygiene and health and nutrition. Key operations such as health, housing and feed management systems are critical for both the large commercial broiler farmers as well as small-scale farmers (Aviagen, 2002). Figure 4 shows the major limitations to broiler growth. The limits suggest the operations that should be in place for successful broiler productions. The key operations are discussed briefly.

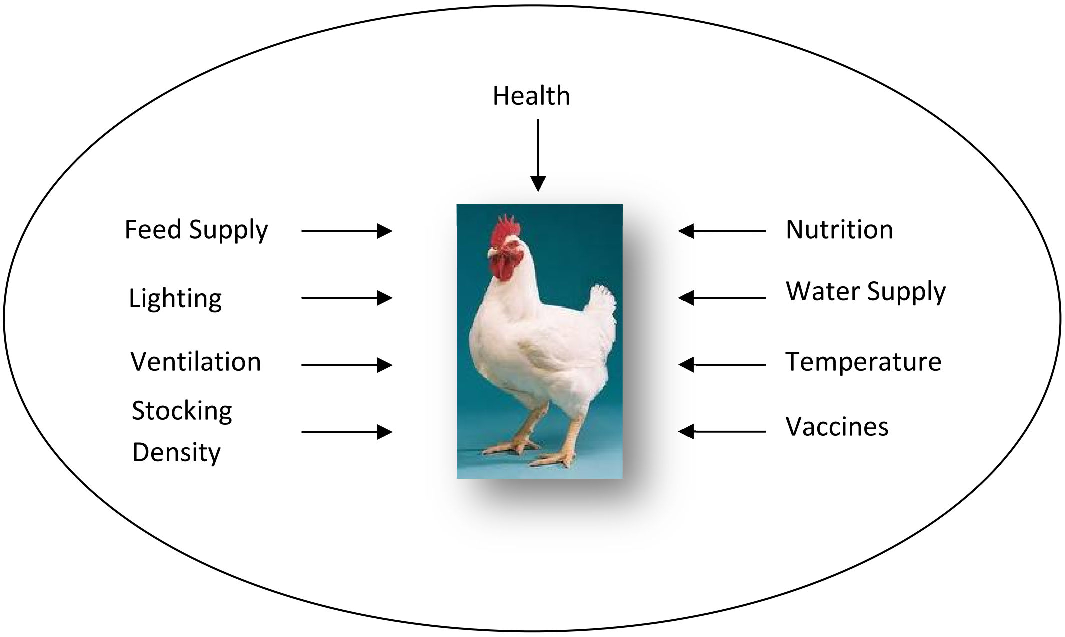

Figure 4 Limits to broiler growth and quality (Adapted from Aviagen, 2002)

Health/Biosecurity

Biosecurity refers to those measures taken to prevent or control the introduction and spread of disease (Department of Agriculture, 2009). Major viral diseases include: Newcastle Disease, Infectious Bursal Disease, Fowl Pox and Marek's Disease. The bacterial diseases are Fowl Typhoid and Salmonellosis, Colibacillosis, Infectious Corrhyza, Fowl Cholera and Mycoplasmosis (Nyaga, 2007).

The objective of biosecurity should be to maximize the flock performance by minimizing or preventing poultry diseases through implementing and maintaining good husbandry and good management procedures throughout the broiler production process (Aviagen, 2002).

Prior to poultry production, a risk assessment should be conducted for each broiler farmer's enterprise to establish the level of risks specific to the farmer's location and production practices. General biosecurity management techniques are briefly described below (Aviagen, 2002; Cobb, 2008):

- Prior to production, establish a set of visitation requirements that is applicable to any visitor. A risk assessment protocol could be established which every individual must complete prior to entry.
- Stipulate farm entry protocols. Ensure that all visitors and staff wear protective clothing and footwear. Provide footbaths in front of every poultry house and ensure a change of footwear before entering a poultry house.

- All equipment or machinery brought onto the farm must be disinfected prior to entry of property.
- All vehicles must be cleaned prior to farm entry.
- Stipulate procedures for cleaning poultry houses and equipment after production cycles.
- Ensure that the disposal of dead birds and litter conforms to environmental requirements.
- Poultry houses should have an adequate down time after a production cycle to reduce carrying over pathogens.
- Establish protocols for feed transport, storage and delivery.
- Establish clear procedures for water management and sanitation.
- Establish pest control procedures.
- Farming on an “all-in-all out” broiler system is highly recommended. "All-in-all out" strategies effectively stop the carryover of fragile pathogens on a site and help to control disease problems by reducing bird to bird passage of vaccine strains (Permin & Detmer, 2007).

Feed and Water Supply

Feed is a major component of the cost of broiler production. The objective is to provide feed that satisfies the nutrient requirements of broilers at all stages of their development and which optimises efficiency and profitability without compromising bird welfare or the environment (Aviagen, 2002).

Generally, 3 different rations of feed are fed, namely: starter, grower and finisher rations. Aviagen (2002) recommends a starter diet for the first ten days. Thereafter, the grower feed is fed for 14 days, followed by the finisher ration that should be fed until the day of processing. The starter feed formulation should be based on performance and profitability and should ensure that nutrient intake supports the dynamic growth during this period. Changing from starter to grower ration involves a transition from crumbs to pellets. The finisher ration is the largest cost of the three rations and should therefore be formulated to maximise financial return and be adjusted according to bird age (Aviagen, 2002). Nutrient specification for broilers slaughtered at a live weight smaller than either 1.9kg, or 2.5kg is available in Appendix A. Note: the feed specifications should be used as a guide only. They require adjustments depending on local conditions and markets.

Good quality water is essential, as many biosecurity risks arise in the watering system (Baracho *et al*., 2006). The SAPA Code of Practice stipulates that clean water should be available at all times, unless otherwise prescribed by an attending veterinarian.

Lighting

The SAPA Code of Practice stipulates that light intensity for the first three days should be sufficient to encourage chicks to start eating normally. Thereafter, light intensity should provide adequate illumination for normal feed and water intake (SAPA , 2009). According to Aviagen (2002), lighting should be provided for at least 23 hours of the day for the first week after placement. The near continuous light ensures that chicks have a good feed intake. After the first week, a minimum of 4 hours of darkness is recommended (ROSS, 2010b). Failure to provide at least 4 hours of darkness results in (Aviagen, 2002): abnormal feeding and drinking behaviours due to sleep deprivation; sub-optimal biological performance and reduced bird welfare.

Temperature and Ventilation

Improved environmental control of broiler houses has played an important role in the increase in productivity of the poultry industry (Aradas *et al*., 2005). Correct temperatures are essential through all stages of broiler production. Temperature must be adjusted throughout the production cycle in order to improve feed conversion ratio (FCR), live weight and mortality rates (Aviagen, 2002).

Two basic ventilation systems exist, namely: natural and mechanical ventilation. Natural ventilation relies on natural air movement which can be manipulated by lowering sidewall curtains, or opening flaps or doors and letting outside air flow through the house. Natural ventilation is ideal when outside temperatures are close to the target house temperature (ROSS, 2010a). Mechanical ventilation systems make use of fans and other heating or cooling equipment and have been proven to provide better flock performance and returns worldwide (ROSS, 2010a).

Stocking Density

Stocking density depends on target live weight, climate and season and type of housing system. According to the (SAPA, 2009), a maximum of 15 birds per square meter is allowed.

Generally warmer conditions require a smaller stocking density rate and in colder conditions the stocking density rate could be increased slightly. If the stocking density is increased, an appropriate increase must be made in feed space and drinker availability (Aviagen, 2002).

Vaccines

There are several vaccination methods. Some vaccines are administered via drinking water. Others can be sprayed, whereby the spray enters the mucous membranes of the nostril or the eye and results in formation of antibodies. Another way is by injection, using an automatic syringe in the neck or breast muscle (Jacob *et al*., 1998).

2.2.3 Production Efficiency

Poultry production efficiency has improved immensely over the past 20 years. As seen in Table 2, the average slaughter age was 5 weeks in 2009, with an added 10 day rest period for the poultry housing to be cleaned and disinfected. This is substantially less than the 62 day old slaughter age common in

1968. The increased efficiency is mainly a result of genetic improvement and improved husbandry practices (SAPA, 2010).

Table 2 Increased production efficiencies in the broiler production of South Africa (SAPA, 2010a)

Year	1968	1998	2004	2009
Average slaughter age (days)	62	42	38	35
Live weight (kg)	1.18	1.79	1.82	1.85

2.3 Poultry Breeds in South Africa

2.3.1 Indigenous Breeds

Poultry production in most rural parts of South Africa is characterized by small scavenging operations, and slow growing indigenous chickens that are considered unprofitable (Norris *et al*., 2007). These indigenous or local breeds are usually selected for their hardiness and ability to withstand harsh environmental conditions (Branckaert & Gueye, 2005). Furthermore, Branckaert & Gueye (2005) found that farmers from sectors 2 and 3 (see Section 2.2.1), who purchased more productive broiler breeds, generally had high mortality rates.

Fowls for Africa is a project within the Agricultural Research Council (ARC) in Irene, South Africa. The aim of Fowls for Africa is to promote poultry breeds that are adapted to the African environment and to provide the necessary extension, knowledge and resources to small-scale poultry producers and extension officers in Africa (Agricultural Research Council, 2006). Examples of indigenous breeds include the Potchefstroom Koekoek, Nacked Neck, Venda and Ovambo breeds.

Potchefstroom Koekoek

The Potchefstroom Koekoek (Figure 5) was bred by crossing the Black Australorp and the White Leghorn and is recognised as a locally developed breed.

Figure 5 Four week old Potchefstroom Koekoek chicks with the Potchefstroom Koekoek X Ross genotype visible in the far right corner

The Potchefstroom Koekoek is a hardy dual-purpose breed that lays brown eggs. At slaughter age the Potchefstroom Koekoek has very attractive deep yellow meat. Weight at 16 weeks of age is approximately 1.84 kg (male) and 1.4 kg (female) and sexual maturity is reached at 130 days (Agricultural Research Council, 2006). The meat is very popular among local communities and preferred above hybrid broiler meat (Grobbelaar *et al*., 2008). Because of its inefficient performance traits, the Potchefstroom Koekoek is not produced by large commercial integrators (Agricultural Research Council, 2006).

2.3.2 Commercial Lines

Commercial broiler producers focus mainly on the efficiency of growth and often use Ross or Cobb lines. The New Hampshire, Black Australop, and Rhode Island Red are examples of dual-purpose breeds that are still used in intensive systems for either meat or egg production. These breeds form the genetic basis of the commercial lines (NAFU, 2008).

Aviagen produces a range of broiler lines that are suitable for different sectors of the broiler market. The range Ross 308, was briefly examined. Ross lines (Figure 6) are known for their improved performance traits which are: feed conversion ratio, liveability and meat yield. These performance traits are all dependent on the environment in which birds are bred, feed formulations and production processes (Aviagen, 2002).

Figure 6 A typical 35 day old broiler produced by the Ross line (Filmer, 2010)

Other important broiler lines used in South Africa are Hubbard and Arbor Acres.

Crossbreeding of commercial lines with South African indigenous chickens

According to Haitook (2006), Prachyalak & Chomchai (1995) and Stromberge (1996), crossbreeding of commercial lines with local or indigenous breeds improves the genetic structure of indigenous breeds. In South Africa, extensive research has not been done to determine the production potential of crossbreeding indigenous chickens with commercial lines. The growth and other production parameters of the cross between an indigenous and commercial line have not been adequately studied and very little has been done, in terms of genetic improvement, to improve their productivity.

3 Contract Farming

Contract farming (CF) has existed from as early as ancient Greek times. In ancient Greece the practice of CF was linked to repayments of dept, rent and tithes. At the end of the nineteenth century, share-cropping was used to deduct rent payment in the United States. It allowed for between one-third and one-half of crops being deducted for rent purposes (Eaton & Shepherd, 2005).

Contract farming can be defined as an agreement wherein a farmer/primary producer agrees to supply a pre-agreed quantity of a certain quality produce at a certain pre-agreed price and time to a known buyer (Sukhpal, 2005). It is also known as an outgrower scheme or satellite farming.

Generally, 3 types of contracts exist, namely:

1. Procurement contracts: under which only sales and purchase conditions are specified.
2. Partial contracts: only some of the inputs are supplied by the contracting firm and produce is bought at pre-agreed prices.
3. Total contracts: under which the contracting firm supplies and manages all the inputs on the farm and the farmer becomes merely a supplier of labour and land.

3.1 Contract Farming for Small-Scale Farmers

Contract farming arrangements, especially in developing countries, grew considerably during the 1970s and 1980s. During this time governments and donors hoped that CF would bring about improved incentives, increased income for farmers and would create a positive multiplier effect for improving rural economies (Kirsten & Sartorius, 2002). Most of these arrangements were multipartite, therefore, involving private firms, government, non-governmental organisations (NGO), parastatal bodies and international aid or lending agencies, such as the United States Agency for International Development, the World Bank and the Commonwealth Development Corporation (Glover, 1987; Little & Watts, 1994).

Contract farming arrangements have experienced mixed outcomes regarding the successes and failures. In Africa, CF has been observed to disrupt power relations within farm households; to exploit an unequal power relationship with growers; and to lead to growers becoming overly dependent on their contracts (Key, 1999). Little & Watts (1994) examines a number of case studies in sub-Saharan Africa, focussing on similar issues such as those which Key (1999) points out. Issues included: conflicts between farmers and the contracting firm; unequal power relationship between the two parties; intra-household tension over new revenues and the increasing rural inequality as contract farmers grew wealthy enough to hire farm labourers.

Nevertheless, successful CF arrangements exist, and despite the issues pointed out, Little & Watts (1994) concludes that income is generally increased through contractual arrangements. In the early 1990's, Porter & Phillips-Howard (1997) reviewed CF in Africa and also concluded that, generally, farmers were better off as a result of their participation in CF in spite of a number of social problems that arose. Other successful CF arrangements involved small-scale farmers in Latin American countries: In Guatemala, small-scale farmers are contracted to produce broccolli and snow peas for export to the United States. In Ecuador, the multinational company, Frito Lay have a contractual arrangement to produce a particular variety of potato for the domestic market (Begum & Alam, n.d.). Other case studies which prove succesful incorporation of small-scale farmers include: Mexico, where the CF arrangement involves frozen vegetables and processing tomatoes (Key, 1999); confectionery peanuts in Senegal (Warning & Key, 2002); and various agricultural commodoties in Indonesia (Patrick, 2004).

3.2 Key Preconditions for Successful Contract Farming

The primary precondition for any investment in contract farming must be that it would be likely to be profitable (Eaton & Shepherd, 2001). The other important preconditions, as mentioned by Eaton & Shepherd (2001), involve the physical and social environments as well as government support.

Profit for the integrator and grower

The contract farming arrangement should benefit both the integrator and the farmer, so that both would make a profit.

Physical environment, utilities and communication

The physical preconditions that must be met include the area topography, climate, soil fertility, water quality and access to utilities such as gas and electricity (Eaton & Shepherd, 2001). For this project, it is assumed that the physical environment and utilities adhere to all requirements for a broiler production to be profitable.

Another major precondition is that the locations of the growers are in relatively close proximity to one another (Kirsten & Sartorius, 2002; Key, 1999). The distance between farms should not be so close that it poses a threat to biosecurity, but rather sufficient so that transport costs are minimized and biosecurity measures are in place. The growers should also have the necessary road infrastructure, telephone and other telecommunications services in place.

Government support

A thorough set of laws and policies by the government are preconditions for CF. Governments have to play an important role in the CF arrangement because of the impact they could have on a contractual arrangement. More so, governments have the ability to develop links between farmers and integrators and can also protect the farmers by ensuring that integrators are financially stable. Such examples are investigated:

In the Philippines, for example, fast food stores imported frozen fries. Although that particular potato could be grown in the Philippines, the government had imposed import restrictions on seed potatoes, resulting in the unavailability of a required variety of potatoes. After companies had approached government and the ban had been lifted, two CF ventures were established and the fast food retailers were supplied with potatoes. This example indicates that a simple policy reform can ultimately benefit both the farmers and the sponsors (Panganiban, 1998).

While not regarded as a precondition for CF, government could also play an arbitration or dispute resolution role. For example, the Malawian government established dispute resolution guidelines for agricultural contracts and offered the services of the Minister of Labour to mediate (Eaton & Shepherd, 2001). Another example involves thousands of potato growers in Canada. These farmers negotiate prices and contract terms through the offices of the New Brunswick Potato Agency (Glover & Kusterer, 1990).

The government can play a major part in the development and promotion of CF. Where CF becomes increasingly known and popular, government may reallocate resources towards its promotion. For example, the Philippinian government promoted CF by allocating land under the Agrarian Reform Programme. Together with a FAO project, forums were held that allowed agribusiness entrepreneurs to meet with farmers' representatives to discuss requirements. The forums were followed with more detailed discussions between the agribusiness and farmers' organization or individual cooperatives or farmers. As a result of this programme, 27 companies had established contractual relationships with farmers within the period of the programme. The Department of Agrarian Reform also assisted in market analysis. They highlighted products that could be produced under contract for which there was a commercial demand and also agreed to act as arbitrator in the case of disputes (SARC-TSARRD, 1998). Another example where government promoted CF was seen in India where the regional office of a government-owned bank organized a meeting with bankers, agribusiness executives and the government extension service with the purpose to explore and determine market linkages for products. This led to a major poultry contracting scheme where 2200 farmers in 164 villages grew maize and soybeans for feed purposes. The finance was provided by the banks, with a tripartite agreement being signed by farmers, the company and the banks (National Bank of Agriculture and Rural Development (NABARD), 1999).

3.3 Contract Farming: Advantages and Disadvantages

3.3.1 Advantages to the Farmer

The prime advantages of a contractual agreement for the producer is that the investor will normally undertake to purchase all produce that adheres to quantity and quality parameters (Eaton & Shepherd, 2005). This shows that the arrangement is a way of allocating risk. From the farmer's perspective, market risk is therefore reduced (Da Silva, 2005; Dorward *et al*., 1998; Key, 1999; Eaton & Shepherd, 2005).

The transfer of skills is obtained through extension services. This may include, among others, improvement of managerial skills and production practices. However, research shows that extension services have not been successful. Hayward & Botha (1995) identified a wide range of problems, pointing out that the quality of extension services is poor, extension methods are out of date and that there was a lack of coordination between the Departments of Agriculture and Agricultural Corporations.

Other advantages include (Eaton & Shepherd, 2001):

- Provision of inputs and production services
- Access to credit
- Introduction of appropriate technology
- Guaranteed and fixed pricing structures
- Access to reliable markets

3.3.2 Problems for Farmers

Literature suggests that the major problem famers' face is that of production risk (Kirsten & Sartorius, 2002; Singh, 2002). This point is widely argued where the advantage suggests that production risk is minimized due to provisions of input and technical assistance (Bijman, 2008). However, as mentioned, the quality of extension services may be poor and it can therefore be seen as a disadvantage due to the need to meet contractual obligations or no salary or payment is obtained by the farmer (Kirsten & Sartorius, 2002).

- Manipulation of quotas and quality specifications

Contractors might renege on contractual terms if market circumstances change and manipulate the quality standards in order to reduce purchases, whilst appearing to honour the contract. This would happen for instance when market prices are lower at product delivery than what the contractor agreed to pay. The contractor can easily manipulate quality standards and even reject the delivered product. In such instances it may be difficult for farmers to check the validity of the contractors' claims as the farmers have no method of disputing such grading irregularities (Kirsten & Sartorius, 2002). All contracting farming ventures should therefore have forums where farmers are able to raise concerns and grievances on such matters.

- Domination by monopolies

Monopoly tendencies occur where one single crop is purchased by one buyer, especially if farmers are locked into a sizable investment and cannot merely start producing other crops. Farmers can be protected by government if they have some role in determining prices paid to farmers. According to Dorward *et al*. (1998), increased competition among traders or firms to prevent monopolistic control (this, however, creates opportunities for side-selling, leading to problems of contract enforcement) is a precondition for a successful contract between farmers and agribusinesses.

- Indebtedness

As mentioned earlier, credit provided to farmers is seen as one of the main attractions and reasons as to why farmers enter into CF arrangements. However, if the agribusiness firm does not provide proper technical advice, extension services, or if market conditions change significantly, contract farmers may incur considerable amounts of debt (Little & Watts, 1994).

- Corruption

According to Eaton & Shepherd (2001), governments have sometimes fallen victim to companies who have seen the opportunity for a quick profit. Some techniques explained, included: charging excessive fees to manage a government owned venture or persuading the government and other investors to set up a new CF company and then to sell that company with poor quality equipment at an over-priced rate.

3.3.3 Advantages to the Agribusiness Firms

The transaction cost and quality inconsistency in CF is widely argued in literature. Bijman (2008) argues that transactional costs are reduced by screening and selection costs, whereas Barry *et al*. (1992) suggests transaction costs are increased as a result of the structuring and administration which in turn leads to fewer contractors willing to form a contractual agreement with smallholders.

Other advantages to the agribusiness include:

- Political acceptability

It is often viewed as politically correct to involve smallholders in CF who would otherwise have difficulty entering the market. In Africa, especially, governments are promoting CF as an alternative to private, corporate and state owned farming. This can be seen in Zimbabwe, for example, where CF is actively encouraged, particularly in the cotton, sugar-cane and tea industries (Eaton & Shepherd, 2005).

- Overcoming land constraints

It is often difficult to obtain land that is affordable, in the correct environmental area and that is large enough for production purposes. CF offers the possibility to obtain the necessary economies of scale without even having to purchase land (Eaton & Shepherd, 2001).

- Production reliability and shared risk

The use of CF allows the sponsors to share the risk of production failure. The production risk is especially reduced where a number of farmers produce for one organization, cooperative or agribusiness firm.

Quality is increased due to the technical assistance that is provided by the contractor (Bijman, 2008). However, Kirsten & Sartorius (2002) states that this is only true for larger contract farmers as evidence indicates that more agribusiness firms prefer to contract with larger farmers in order to reduce transaction costs and achieve greater consistency. This is in contrast to Eaton & Shepherd (2001) who suggests that small-scale farmers are more likely to produce high quality products than farmers who must supervise hired labour.

3.3.4 Problems for Agribusiness Firms

The problem of high transaction costs is a frequent argument in the literature on CF especially in developing countries. According to Key (1999), transaction costs are increased when small farmers are spatially dispersed and when farmers make frequent deliveries.

Other problems as described by Eaton & Shepherd (2001) include:

- Land availability constraints

Problems arise if land restrictions, access and land use are not specified in the contract. It is important for a contractor to know what the rights of the farmers are on the land before contracting with them as well as attaining legal rights of access to the farm.

- Social and cultural constraints

Problems arise if contractors choose farmers who do not comply with strict timetables and schedules due to social obligations. Innovation and technologies may also be jeopardized by traditional or cultural practices. Before contracting with a farmer, the contractor should familiarise himself with the farmer's social/traditional and cultural background.

- Extra-contractual marketing

The tendency of certain farmers to sell the produce obtained from an agribusiness firm to a third party is always a problem for contractors. The farmer is usually able to sell to an alternative market which offers more money for the produce. The contractor should create incentives for farmers to deliver only for the contract.

- Input diversion

Farmers are sometimes tempted to use the inputs that they obtain from the agribusiness for other purposes. If inputs are used for other purposes this will reflect in the quality of the produce. Contractors should therefore monitor the farmers and ensure that farmers use inputs for the intended purpose. Should inputs be used for other purposes, strict consequences should be enforced.

The literature on broiler practices and contract farming give us a concrete basis on which a feasibility model can be based. Literature on bio-economic models is reviewed in Chapter 4 to ensure that models are constructed correctly.

4 Bio-economic Models

Communication between scientific realms is difficult because scientists from various disciplines speak different languages (Hengsdijk & Kruseman, 1993). To overcome these difficulties, quantitative approaches have been developed which allow successful communication between different sciences. These are commonly referred to as bio-economic models.

This chapter gives an overview of bio-economic models and reviews a number of different bio-economic models found in various agricultural fields.

When dealing with bio-economic models two components exist. The first component involves socio-economic aspects relating to household behaviour, market structure, institutional arrangements and policy incentives. The second component deals with the resource degradation in terms of its biophysical processes related to, for example: water, plant and animal growth. The analysis of agricultural systems therefore requires contributions from both the biophysical sciences and economics.

4.1 What is Bio-economic Modelling?

King *et al*. (1993) defines bio-economic models as:
"A bio-economic model is a mathematical representation of a managed biological system. Bio-economic models describe biological processes and predict the effects of management decisions on those processes. They also evaluate the consequences of management strategies in terms of some economic performance measures". The emphasis of the above definition is on the management of biological processes.

4.2 Why Bio-economic Modelling?

System models provide a simplified description of important system components and their interactions. Schoemaker (1982) identifies four purposes for systems models: 1) description, 2) prediction, 3) postdiction, 4) prescription. Descriptive models are used to characterize the system. Their performance, in turn, allows modellers to evaluate whether they have adequately described the important aspects. Predictive models forecast future system behaviour. Descriptive models may serve a predictive purpose, but many predictive models are much simpler than descriptive ones, especially when certain system patterns repeat themselves systematically, obviating the need to describe the underlying mechanisms. Postdictive models tend to be human logical constructions that allow us to explain, after-the-fact, which system constraints or special phenomena resulted in a given outcome. Prescriptive models are normative ones that offer guidance on how a system should be managed to meet a specific goal. Many agricultural models serve more than one of these purposes.

The design objectives for bio-economic models are (King *et al*., 1993):

1. Theory building. Bio-economic models can contribute to theory building by establishing a common vocabulary for inter-disciplinary work.
2. Tool development. The systematic formal mathematical representation of the relationships of a problem permits solutions developed for one application to serve as a basis to confront challenges found in others. This is especially relevant for the biophysical processes involved.
3. Technology and policy assessment.
4. Decision support. Models developed as decision-support systems can aid farm management decisions, e.g. precision farming.

Another reason for modelling agricultural systems is to improve knowledge of the system. Areas where knowledge of the system is unclear, fuzzy or missing tend to become apparent throughout the process of designing the model structure. Knowledge is also improved when parameters are adjusted in order to make empirical models operational. Such knowledge improvement is explained through an example of the weed industry.

A weed management model was developed which revealed that in the past 30 years, North American weed scientists have focused their research so heavily on herbicide performance that little is known about weed biology and ecology. The modelling process helped to instigate a new research effort in this area (Forcella *et al.*, 1992). Model design experiences often lead to revised priorities for future data collection research, based on data gaps defined (Dalton, 1982). Hence, systems modelling may provide value, not just through the end-product model developed, but also through the development process itself.

4.3 Key Features of Bio-economic Modelling

Based on the findings of Brown (2000), the following are key features that need to be considered when dealing with bio-economic models:

Dynamic and recursive process modelling

The dynamic interfaces between the economic and biophysical components are important for the following reasons:

- Biophysical components respond dynamically to environmental change.
- The impact of the decisions taken by the modeller, need to change dynamically in the biophysical component as well as the economic component where necessary.

As in a multi-period budget, inputs to the one year affect the outcome of that year, which is then used as an input for the next year. Thus, decisions taken at a single period of time influence the forthcoming periods analyzed.

Temporal and spatial scale

Models of agricultural systems can be classified according to space, time and hierarchical organization.

The timescale is important because humans often model decisions on an annual or monthly basis. Biological processes, on the other hand, are unique and are based on growth and development. Broiler inputs and outputs depend on the length of the cycle period. Interaction between the modeller and biological timescale should therefore be integrated in the best possible way.

Prescriptive or predictive

Prescriptive models optimise and assess the consequences of any change in the system. They show how reality diverges from what the models suggest and can therefore be used to indicate possible ways of moving towards the modelled optimum. The models are also used as a guidance tool on management for obtaining a specific goal. In essence, prescriptive models describe what should be done if certain objectives were to be achieved. E.g. Objective: to break even on selling price/kg broiler meat. Given gross profit and direct operating costs, what should the selling price/kg broiler meat be in order for the broiler farmers to break even?

Unit of analysis and decision making level

The decision-making unit can refer to an individual, household, farm or some other larger unit such as a village or community. The unit of analysis depends on the purpose of the model and will therefore be decided upon after objectives are specified.

4.3.1 Broiler Models

Deterministic and stochastic bio-economic models enable linking biological parameters with economic indices, a feature that makes such models useful instruments for evaluating investments in broiler projects. One of the first deterministic models used for evaluating a broiler production was described by Groen *et al*. (1998). The model distinguishes between four production stages: multiplier breeder, hatchery, commercial grower and processor. The model analyzes the profitability of a project and can be applied to different poultry projects by changing the exogenous parameters (biological, feed, prices). In Menge *et al.* (2005), a deterministic model was developed to evaluate biological and economic variables that characterize indigenous chicken production systems in Kenya.

4.4 Research Questions

On the basis of the objectives stated in Chapter 1, together with what was learnt from the literature review, the following research questions are derived:

1. Can small-scale farmers benefit economically if they farm under contract?
2. Will a crossbred broiler genotype perform better in the environment in which small-scale farmers produce broilers?

Methodology

5 Bio-economic Model Design

The aim of this study is to develop a model for evaluating the economic feasibility of a small-scale broiler producer. Together with the aim, three different chicken genotypes are evaluated. For the purpose of this study, a small-scale broiler farmer refers to a farmer who either falls into sector 2 or sector 3 (see Section 2.3.1) and who has a production size of 500, 1500 or 2000 birds per cycle.
The following is proposed:

1. Study and Model Type: Predictive and explanatory.
2. Components modelled: Commercial small-scale broiler farming system; Performance traits of different genotypes; Broiler farmer production in Hopefield.
3. Unit(s) of analysis: Base model farm or case study farm.
4. Optimisation alternatives available: Simulates outcome (economic performance).
5. Model output(s): Cash flows, profit and loss statement, multi-period budget.
6. Data inputs: Flock profile, financial inputs, design/management decision, capital inputs, loan, operating costs.

The chapter follows the following structure: Section 5.1 describes the model concept. The model's components are presented in the remainder of the chapter and include detailed descriptions of the biophysical and economic components and model assumptions.

5.1 Concept Model

The aim of the concept model is to create a logical representation of operations in a small-scale broiler contract grower production system. Developing a concept model is critical and helps in planning and developing the model.

Figure 7 depicts the concept of the overall model. The high level inputs into the bio-economic model are: contract grower production inputs and capital, integrator services and inputs, input and output prices. A bio-economic model is developed and grower's financial performance indicators are determined.

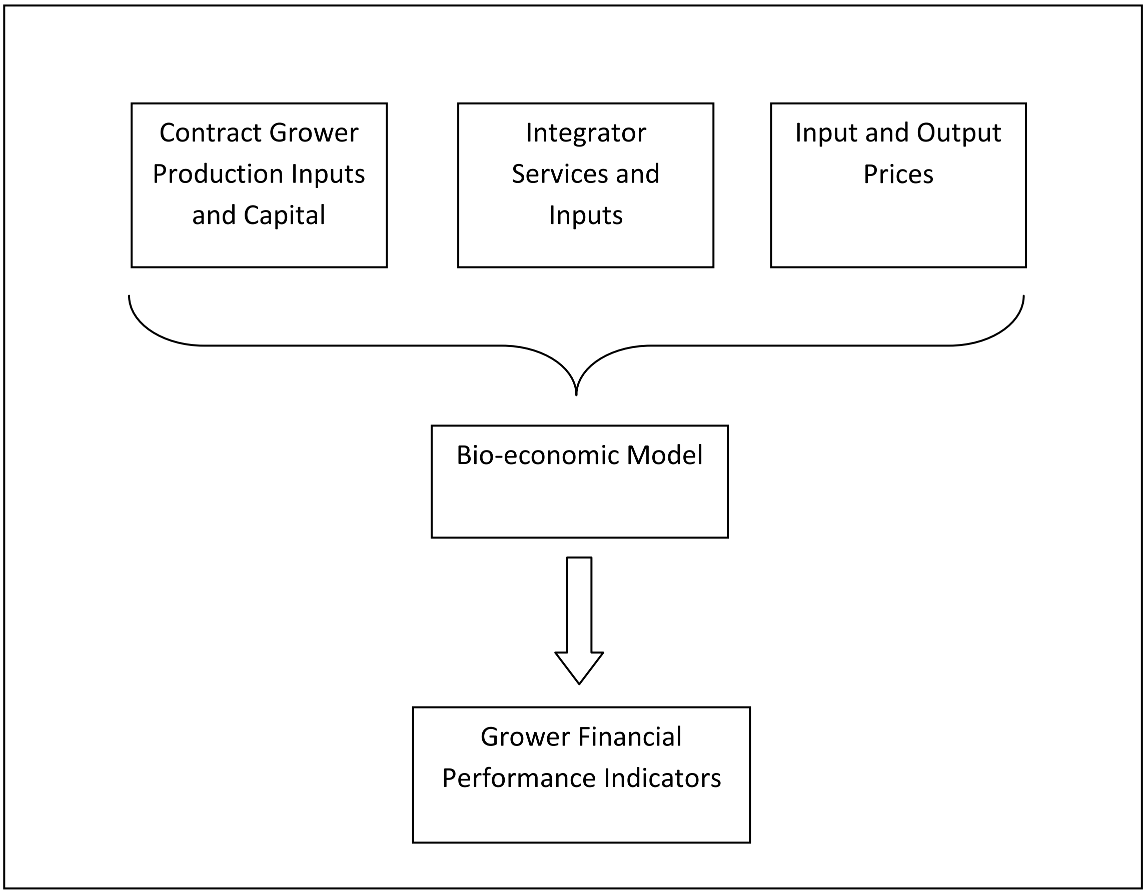

Figure 7 Overall concept model showing the flow of information into the bio-economic model

For the purpose of establishing whether the institutional arrangement, contract farming, is economically feasible or not, the model approach will take on predictive and explanatory features, where the unit of analysis will be the small-scale farmer's farm.

The model is designed so that all inputs are dynamic. This makes the model generic so that the model can be applied to any farmers that have similar farming processes. This section presents the theoretical and mathematical formulation of the bio-economic modelling framework used in this study.

Below is a representation of the structure of the model (Figure 8). Each entity has some input data, as well as a number of logical calculations associated with it.

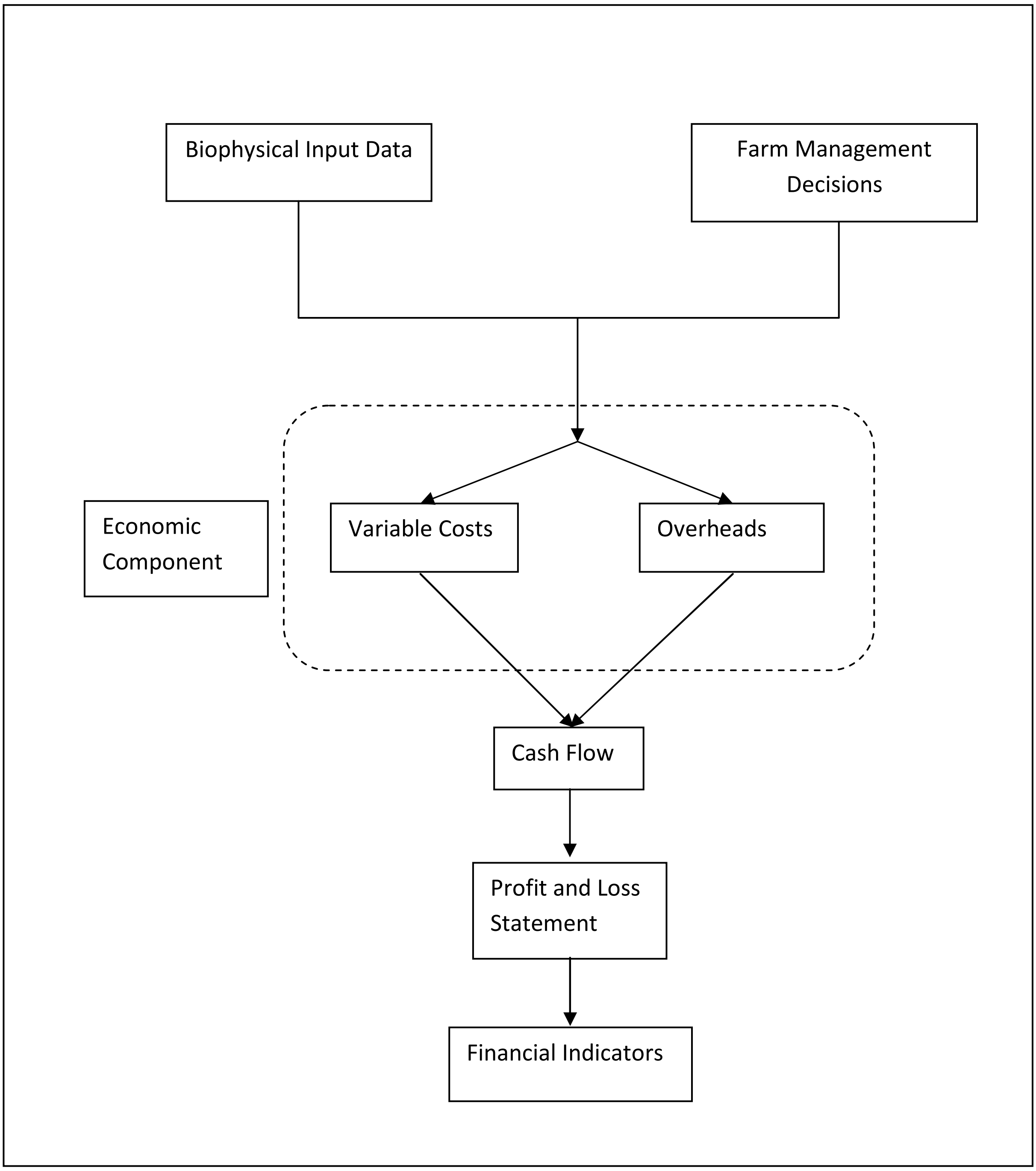

Figure 8 A flow diagram showing the input data used for financial indicators

5.1.1 Biophysical Component

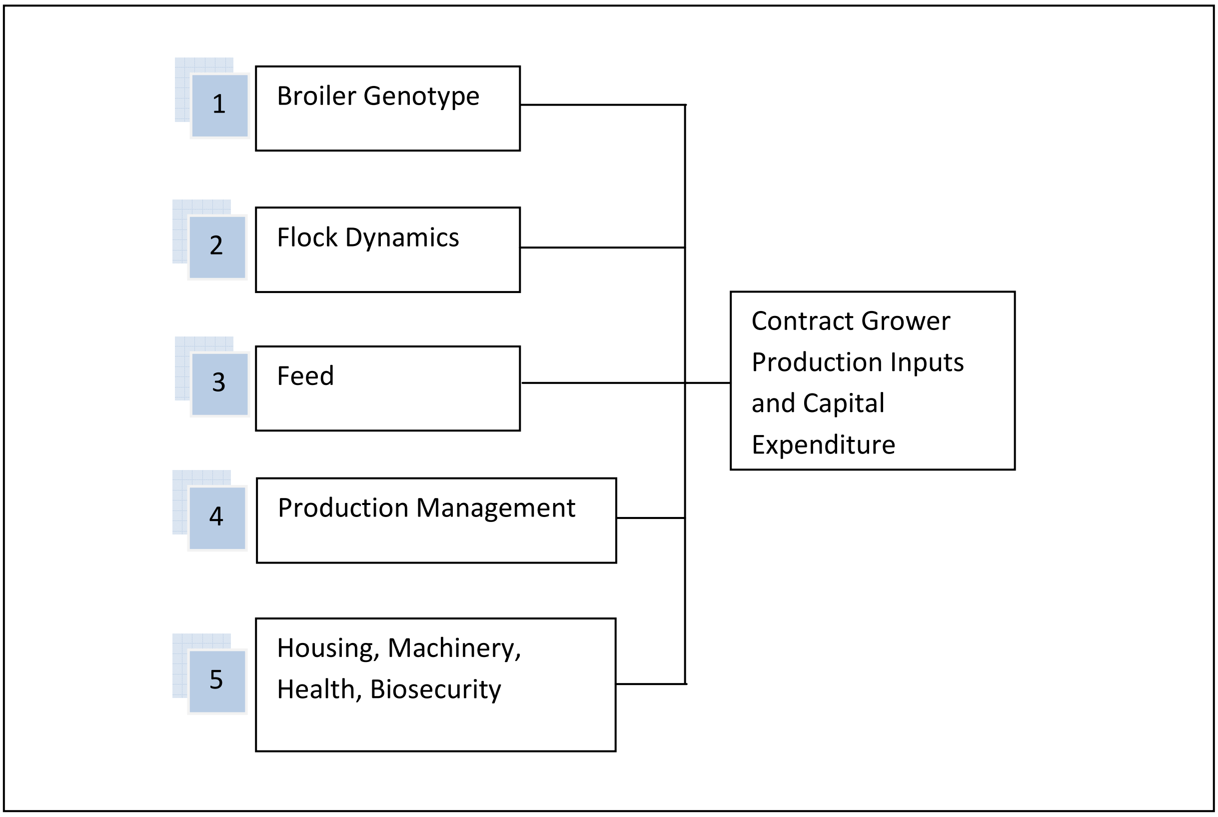

Figure 9 Biophysical component of the bio-economic model

Figure 9 shows the five main aspects concerned with broiler production. These are explained:

1. The genotype refers to the type of chicken used for production.

The model was used to compare 3 genotypes. The strains include the progeny of the indigenous Potchefstroom Koekoek, commercial Hybro hens X Cobb500 genotype (a commercial broiler line) and a cross between Ross 308 roosters (a commercial broiler line) and Potchefstroom Koekoek hens. Key parameters such as feed intake per chick, weight gain per chick, feed conversion ratio, dressing percentage and liveability are compared. The data used for this comparison was collected during a trial done for the purpose of this study. See section 7.2 for the results of the trial.

Growth curves were also investigated so that the relationship between age and live weights could be determined. Different growth curves have different characteristics and different mathematical limitations. It is therefore important to carefully determine the growth curve that best fits the growth of all three genotypes. The aim was to examine whether there are breed differences in the growth parameters of the three genotypes.

2. Flock Dynamics: Table 3 shows the inputs for the flock profile. All inputs are explained by referring to the letter presented in the column on the left of the table.

Note: The values presented in this section are used for illustration purposes only.

Table 3 Biophysical component – Flock Profile

	Flock Profile	
A	No. of chicks placed per cycle	500
B	Mortality rate	0.05
C	No. of birds less mortality rate	475
D	Plant condemnations	0.02
E	No. of birds sold per cycle	465.5
F	Finish live weight (kg)	2.27
G	Dressing %	0.71
H	No. of kg's sold per cycle (live)	1057
I	Chick purchase price	4.8
J	Days to market	35
K	Cleaning period (days)	10
L	Cycle period (days)	45
M	No. of cycles per year	8.11
N	Amount of manure sold per cycle (kg)	288.3
O	Estimated price obtained per kg of manure	2.0

A. The number of chicks placed depends on the farmer's capacity, as well as stocking density.

B. Mortality rate is an estimation of the percentage of birds that will die per cycle.

C. Initial number of birds placed less mortality rate.

D. Plant condemnations refer to the number of birds that do not qualify to be sold for human consumption.

E. Final number of broilers produced successfully = initial number of birds placed less mortality percentage less plant condemnations.

F. An estimation of average live weight per bird at the end of a cycle.

G. An estimated percentage of broiler meat obtained from the live broiler after feathers and intestines are removed.

H. Total number of kg's (live weight) sold per cycle.

I. The price payable to either a private hatchery or contract grower for the chicks.

J. The numbers of days the broilers are raised before being slaughtered. This value is determined from the feed input table where days on each different feed are added together (Table 4).

$$Days\ to\ market\ = Days\ on\ starter + days\ on\ grower + days\ on\ finisher \quad (1)$$

K. The number of days the broiler house stands vacant after removing broilers.

L. Cycle period is the total number of days it takes to raise broilers added to the time allocated to the cleaning period after a production cycle.

$$Cycle\ period\ = Days\ to\ market\ + cleaning\ period \quad (2)$$

M. Number of cycles per year:

$$Nr\ of\ cycles\ (per\ year) = \frac{365}{Cycle\ period} \quad (3)$$

N. Amount of manure sold per cycle is the amount of manure, or chicken litter, sold per cycle.

O. Revenue from 1 kg of chicken manure sold.

3. Feed

Table 4 presents the feed associated inputs. These are explained below:

Table 4 Feed component formulation

	Feed	
A	Days on starter feed	10
B	Days on grower feed	15
C	Days on finisher feed	10
D	Total amount of starter/bird (kg)	0.9
E	Total amount of grower/bird (kg)	1.2
F	Total amount of finisher/bird (kg)	1.2
	Total (kg)	3.3
G	Feed Conversion Ratio	1.65
	Feed Costs	
H	Cost of starter/tonne (R)	3806.6
I	Cost of grower/tonne (R)	3637.2
J	Cost of finisher/tonne (R)	3213.6

Values A, B and C refer to the number of days that a bird feeds on starter, grower and finisher respectively. Values D to F are self explanatory.

Value G refers to the Feed Conversion Ratio (FCR) as presented in Equation 4.

$$FCR = \frac{Amount\ of\ feed\ consumed\ \mathrm{per}\ bird(kg)}{Live\ weight\ (\mathrm{kg})} \tag{4}$$

The feed conversion ratio is a good measure of performance. Some of the largest integrators in South Africa measure their grower's performance based on the FCR. Bonuses are given to their growers who obtain the lowest FCR.

4. Production Management:

Management is an extremely important aspect of broiler production. It is imperative that the broiler production processes, vaccine programme, feeding programmes and health and hygiene practices are managed correctly.

For this study, three sizes of production are investigated. The production scales investigated, include: 500 birds, 1500 birds and 2500 birds per cycle. Together with the different production sizes, different genotypes are investigated. The genotypes also have an impact on management practices as broilers practices will differ for each genotype, due to varying cycle times.

5. Housing, Machinery, Health and Biosecurity

Point 5 refers to a broad range of broiler production features. Firstly, proper housing structures are necessary, especially for small-scale farmers who often rely on natural ventilation techniques. Secondly, machinery, together with the entire house must easily be sanitized after a production cycle. This forms part of biosecurity and health management (see Section 2.2.2).

All of the above biophysical entities have an impact on the financial outcome of the model.

5.1.2 Economic Component

The bio-economic model will be developed to examine the financial feasibility of an individual contract broiler production system over a 10 year period. The model constructs budgets based on detailed itemisation of cost and returns. Standard agricultural accounting principles are used throughout the budget. Firstly, economic input data is described. Thereafter, the assumptions employed for establishing long term financial cost curves over a 10 year period are stated. It should be noted that the assumptions are all dynamic inputs and can be changed if new information is gathered.

Table 5 depicts the financial input data. Inputs are explained as follows:

Table 5 Financial design sheet

	Financial Design Sheet	
	Inflation	
1	Inflation per annum	0.07
2	Inflation per day	0.000185383
	Feed Cost Inflation per annum	0.04
	Feed Cost Inflation per day	0.00010746
	Sale Price Inflation per annum	0.1
	Sale Price Inflation per day	0.000261158
	Chick Price Inflation per annum	0.03
	Chick Price Inflation per day	8.09863E-05
3	Loan Interest Rate	0.09
4	Depreciation Rate	0.1

1. The inflation per annum is associated with most of the direct operating costs and capital costs.
2. Inflation per day is calculated as follows:

$$Inflation\ per\ day = (1 + Inflation\ per\ annum)^{\frac{1}{365}} - 1 \tag{5}$$

Inflation per day is calculated daily so that a daily cash flow can be generated which tells us whether the farmer will be able to pay his or her expenses on a daily basis. Feed cost inflation, sale price inflation and chick price inflation is calculated in the same way as the general inflation per day calculation as shown above.

3. Loan interest rate for small-scale farmers will be 9% per annum (Hoffmann, 2010).
4. Depreciation rate is according to SARS depreciation sheet (Hoffmann, 2010).

Table 6 presents the Techno/Economic Parameters used for the base model.

Table 6 Techno/Economic Parameters

Number	Description of Parameter
1	Number of birds per cycle
2	Rearing period (weeks)
3	Cleaning period after a cycle (weeks)
4	No. of batches per cycle
5	No. of cycles per annum
6	Space requirement per bird (m^2)
7	Cost of Unit
8	Mortality % in rearing period
9	Cost of day old chicks
10	Feed Cost (Starter, Grower, Finisher)
11	Overhead Costs/Bird
12	Variable Costs/Bird
13	Average carcass weight of birds (kg)
14	Price of broilers (R/kg broiler meat)
15	Depreciation on buildings (%)
16	Depreciation on equipment (%)
17	Interest rate (%/annum)
18	Repayment Period (Years)

Cash Flow

Cash flow generated from a poultry house will change over time as debt is retired and net income changes. Cash flow budgets can be set up in many ways depending on interest rates, payback periods, depreciation schedules and tax rates used. Thus, any cash flow projection is only an estimate of what may be reasonably expected to occur given the input factors available at that time. The following assumptions were made for the cash flow analysis:

- Initial Investment: The initial investment amount depends on whether the scenario investigated includes the initial outflow of constructing a broiler house(s). If houses are constructed the value used for building houses is obtained from an established open sided, small-scale broiler housing construction company. If broiler houses already exist, no initial outflow will be considered but they are taken into account in the multi-period budget which analyses the net present value.

- Annual Net Income: Annual gross income minus annual expenses.
- Depreciation is not a cash expense and is therefore not included in the cash flow. It is included into the profit and loss statement and used in the multi-period to calculate net present value.
- Labour: Added as a fixed expense.
- Land: The cost of land is not included in the cash flow but is included in the multi-period budget as an opportunity cost.
- Value of Litter: The value of used litter is assumed to be zero. The model does however allow for litter sales and if litter sales are included, it will be reflected in the cash flow.
- Net Cash Flow: Management and marketing costs are not included. Net cash flow is determined by subtracting the interest from the net income.

Profit and Loss

The profit and loss statement follows a specific format. The gross profit is calculated by deducting the direct cost of sales from the income value. Farm profit income is calculated by deducting overhead costs, as well as depreciation. Deducting interest provides the net profit before tax.

$$gross\ profit = sales - direct\ operating\ costs \tag{6}$$

$$net\ farm\ income = gross\ profit - overhead\ costs - depreciation \tag{7}$$

$$farm\ profit = net\ profit\ before\ interest\ and\ tax - \ interest \tag{8}$$

$$net\ profit = net\ profit\ before\ tax - tax \tag{9}$$

Multi-period Budgeting

The multi-period budget is used to determine the Net Present Value (NPV) of the farm as well as the Internal Rate of Return over a long period of time. These financial indicators are explained:

An investment is seen as being worth undertaking if it creates value for its owners. In a general sense, this is defined as an operation that creates value and is therefore worth more in the marketplace than it costs to acquire. The NPV is defined as the difference between an investment's market value and its cost (Firer *et al*., 2008). The rule for NPVs is that an investment should be accepted if the NPV is positive and rejected if the NPV is negative.

The NPV is calculated by discounting all of the cash flows of an investment (including the investment cost) to the present time, using a discount rate. The calculation of the NPV is a relatively simple one, but the task of determining the appropriate discount rate, as well as predicting the future cash flows, is much more challenging (Firer *et al*., 2008). The formula for the NPV is as follows.

$$NPV = \sum_{t=1}^{T} \frac{cash\ flow\ (t)}{(1 + discount\ rate)^t} \quad (10)$$

The internal rate of return (IRR) is defined as the discount rate that makes the NPV of the investment zero.

$$0 = \sum_{t=1}^{T} \frac{cash\ flow\ (t)}{(1 + discount\ rate)^t} \rightarrow solve\ for\ discount\ rate \quad (11)$$

The rule for making decisions using the IRR indictor is to accept an investment if the IRR exceeds the required return.

A problem that arises with the IRR rule occurs when comparing two investments that are mutually exclusive (implying that taking the one investment prevents the taking of the other). The IRR rule can sometimes return misleading results, causing one to choose an investment over another that has a higher NPV. Therefore, when considering mutually exclusive investments, the IRR rule should not be used on its own. The NPV together with the IRR can be used when comparing two mutually exclusive investments.

Therefore, when comparing the 3 different broiler scales of production with one another, both NPV and IRR are used. If different genotypes are compared within the same scale of production, the NPV is satisfactory.

Farm Management

The management and decision making of broiler producers play a vital role in the economic outcome of a broiler production. Firstly, the type of contract formed between farmer and firm is important. For this study, the type of contract is chosen to be a procurement contract (see Chapter 3). The model can be modified with relative ease to suit any type of contract.

After establishing the contract, farmers may produce a specified amount of broilers at a specified time. Due to the nature of the contract and various management decisions that have to made on a daily basis, management thereof is extremely important.

In the case of a procurement contract, many decisions such as what feed to feed, vaccination programmes to follow and general farming management techniques are required.

Besides the physical production management, financial management is crucial. The small farmer does not necessarily have cash on hand to pay all his/hers expenses prior to the production cycle. This study does not delve into the physical management aspect of broiler production and assumes standard management guidelines (as provided by the companies supplying the broilers such as the Ross- or Cobb broiler manual which are detailed management manuals). However, financial management is included through including dynamic inputs as to when a farmer would generally pay for his/her expenses.

The model includes a design sheet which the farmer or analyst could use to design payment schedule. The time of payment for every expense relating to a broiler production can dynamically be changed in order to examine the impact on the daily cash flow.

5.2 Verification and Validation

The verification and validation of a bio-economic model is a continuous process that starts from the development of the model right through to the final model. Verification concerns the ability of the model to comply with the model specifications and assumptions made in the conceptual model, therefore investigating the correctness of the bio-economic model. Verification is also known as debugging. Validation on the other hand confirms that the model has been built for the correct purpose. Both verification and validation were applied throughout the building process of the model. The purpose of this section is to discuss the techniques used to verify and validate the author's model.

Verification

As with all farm-scale models, the overall model is difficult to verify as appropriate detailed data of all the components of broiler production systems are not always included. The only way to 'test' the model is by discussing the outcome of the model with experts and to conclude whether the results make sense. The model can therefore also be seen as an exploration tool which quantifies the consequences of decisions taken by the farmer (e.g. allocation of resources) on the longer term productivity of the system. The following techniques were used to verify aspects of the model:

1. Correcting error messages in the model, which prevent the model from running.
2. Checking every input into the model and to verify that the linked values change in according to the created one.
3. Experts reviewing the model. A structured "walk-through" the model was conducted with an agricultural economist (Hoffmann, 2010).
4. Running the model under different input parameter values to test the reasonability of the output parameters.

Validation

Several steps have been followed to ensure the validity of the bio-economic model's results. Firstly, discussions, ranging from contractual arrangements to variable costs of production, were held with a variety of people (Coetzee, 2010; Hoffmann, 2010; Koen, 2010). Secondly, data on representative farm budgets were investigated from various sources such as journals and textbooks (Goodwin *et al*., 2005; Leuning, 2003; CNFA Bagh, 2008; FAO, 1999; Cunningham, 1999; Doye *et al*., n.d.).

5.3 Shortcomings and Limitations

- Although genetic links exist, no direct relationships between performance traits of different categories, (e.g., male vs. female) are considered. All birds are fed standard rations and are not fed according to genotype.
- Parameters on genotypes could also be compared in terms of production systems (free-range vs. intensive). The comparison would give valuable information with regards to the suitability of the genotypes in such a production system.
- Furthermore, the model does not include any aspect of probability, thus stochastic modelling could also be applied to parameters.
- The model does not cater for any growth in production scale and therefore assumes a certain level of production for a 10 year period.

5.4 Model Application

The model can be used as a management tool. Due to the dynamic, explanatory and predictive nature of the model, the model can be used to evaluate the impact certain decisions have on the profitability of the farm, for example: increasing or decreasing production size or production cycle times. The model can also be used to evaluate the impacts of higher mortality rates and fluctuating bird prices on the profitability of broiler farms. In addition, the model can be used to evaluate the impact of interest rates and debt financing levels on the small-scale contract broiler growers.

5.5 Summary

The model has been described and developed in this chapter. Main operations modelled and the activities that are involved with the operations were explained. The concept forms a crucial part of the modeller's knowledge and understanding of the broiler production system before proceeding to the model results.

Furthermore, the chapter illustrated the reasons and methods used for building the model. The design explained the following aspects of the model: Model assumptions, biophysical components and the economic components.

The chapter concluded by explaining the techniques used to establish the credibility of the model.

The next chapter describes the data collection procedures and the data analysis methods.

6 Data Collection

To recapulate the research questions formed in Section 4.4:

1. Could small-scale farmers benefit economically if farmers farm under contract?
2. Will a crossbred broiler genotype perform better in the environment in which small-scale farmers produce broilers?

The model is used as a tool to establish answers for the research questions. Due to unavailability of data in the small-scale farming industry, commercial data is used as a starting point for the analysis. Firstly, commercial flock profile input data is used to theoretically determine the economic outcome of a small-scale contract broiler grower under an intensive production system. The size of flock will evidently differ; however, input data such as price obtained per kg broiler meat, standard feed formulation, cycle period, dressing percentage and live weight of birds, is used. This model is referred to as the base model. Although many environmental and production processes differ between commercial and small-scale farming, the purpose of the base model is to acquire a sense of what the farmer may expect once farming on a commercial level. The base model can be seen as a "Best Case Scenario" due to the low probability of small-scale farmers actually obtaining commercial production standards.

The base model is also used as a foundation for biological data collected on different genotypes. The base model could be modified and used to evaluate different production systems (i.e. intensive and free-range).

Data comparisons are conducted on three different-sized, small-scale broiler productions. Comparisons are therefore conducted on the scale of production as well as on different genotypes.

Results on data obtained were statistically analysed on 'Statistica 9' and are presented in Section 6.6.

More data is collected through a case study on small-scale broiler farmers in Hopefield. The data obtained is presented in Section 6.3.

Figure 10 gives an overview of the methodology of this study. The results and discussion chapter follows the same structure as the flow of the diagram.

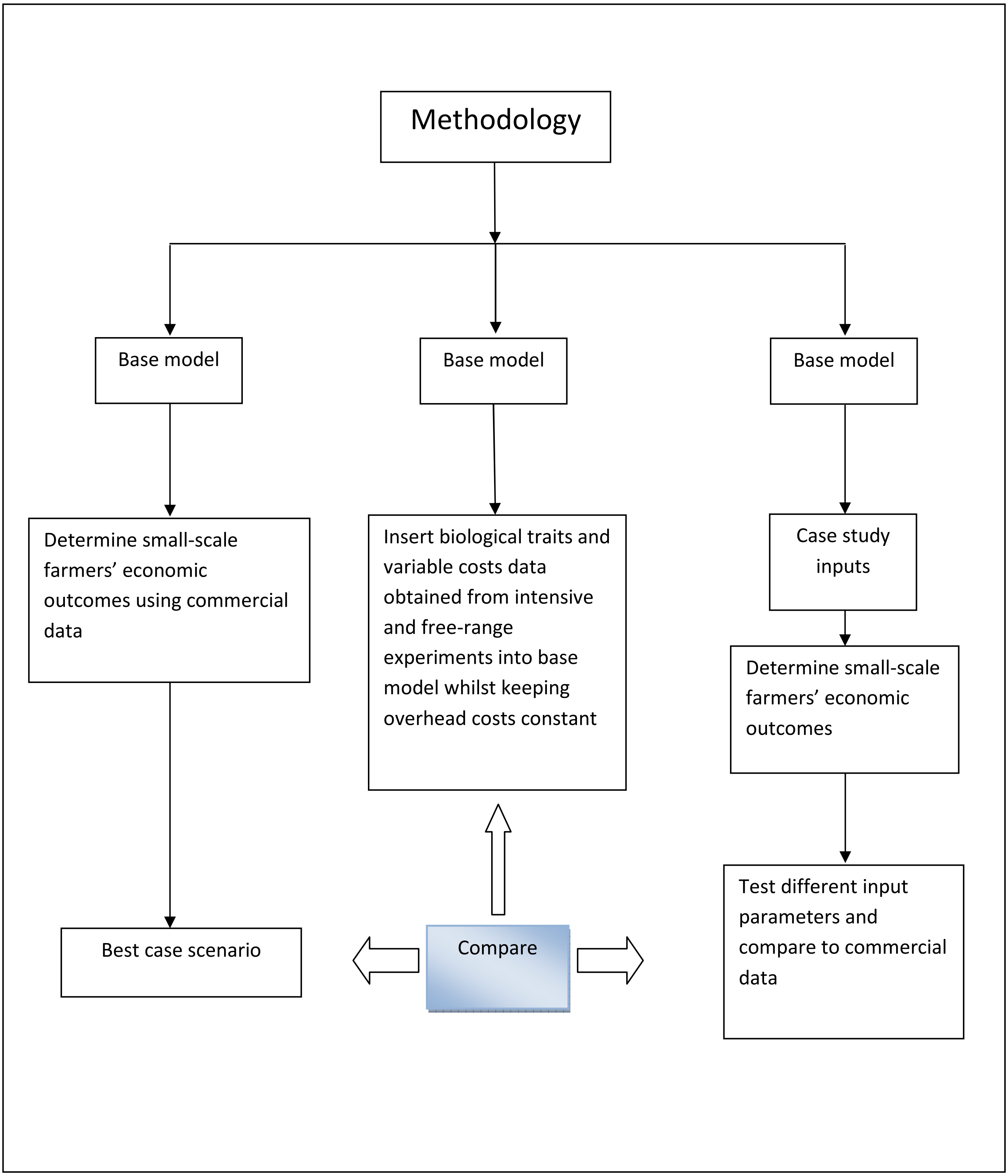

Figure 10 Overview of methodology and data collection processes

6.1 Base Model Data

Firstly, contract grower remuneration aspects needed to be put in place and, secondly, general production input data was collected for commercial standards. Market values as published by SAPA (2010) were used for the remuneration component of the model.

Furthermore, data on production inputs was taken from a Ross manual (Aviagen, 2002). It should be noted that these values are merely estimations and will differ depending on the location of the farm and environmental conditions.

6.2 Experimental Data

The data collection methods used for determining the parameters for three different genotypes under two production systems included observation and, specifically, experimental (controlled) recordings. The materials and methods used are explained below:

Materials and Methods

Birds and housing:

One hundred and ninety two (192) day old chicks, as they hatched (of which 64 progeny of Cobb500 males X Hybro G females, 64 progeny of Ross 308 males X Potchefstroom Koekoek females and 64 purebred Potchefstroom Koekoek) were placed in a mechanically ventilated house. The house was divided into 32 cages, of which the middle 24 were utilised for trial purposes.

Birds, within breeds/crosses, were randomly allocated to cages. The design rendered 3 treatments and eight replicates per treatment with treatment blocked within the house. Feed and water was provided *ad libitum* (continuous supply) from day old. Management practices were in accordance with guidelines of Ross 308.

Treatment:

Treatment was according to genotype.

Diet:

A commercial type three phase diet was fed to the birds with an alternative for including more phases as birds grew beyond the 35 day industry standard.

Measurements and statistical analysis:

Cages were monitored twice daily for morbidities and mortalities. All morbidities were noted and treated accordingly, while mortalities were removed and weighed. All measurements were corrected for mortalities.

Body weight of the birds was measured at placement (day 0) and weekly thereafter until all birds within the cage were slaughtered. Feed was removed three hours prior to weighing. Each cage was weighed and the individual weight calculated as an average.

Feed allocated per cage was measured on days of live weight measurement and feed remaining in feeders was weighed back. Weekly feed intake per cage, as well as feed conversion ratio (FCR), was calculated. At the end of the trial, carcass weight and feed conversion ratio were calculated.

European Production Efficiency Factor (EPEF), also known as the European efficiency factor (EEF), was calculated from data in order to compare treatments in terms of efficiency (Equation 12) (Butcher & Nilipour, 2002).

$$EPEF = (livebility\,\% \times live\ weight\ (kg) \div age\ (d) \times FCR) \times 100 \qquad (12)$$

The EPEF performance indicator can only be measured at the end of a cycle. Historic data on EPEF should therefore be taken so that comparisons can be made between cycles (Manning *et al*., 2008).

Reporting:

After completing the experiment, the data was statistically analysed using 'Statistica 9'. The level of significance was set at $P < 0.05$. The data was entered into the model to compare the different genotypic parameters. The statistics used to analyse the above trials are explained below.

6.2.1 Data Analysis and Statistics

Data obtained from the experimental trials were analysed as follow:

Analysis of Variance was conducted on the following parameters

- Initial day old chick weights
- Feed Intake per chick
- Liveability percentage
- Feed conversion ratio
- European Production Efficiency Factor

6.3 Case Study

Semi-structured interviews were conducted with two small-scale broiler farmers from Hopefield. Production sizes, prices and management techniques were noted. The background of the farmers and their production processes follow.

Background

Hopefield is situated close to the West Coast and is about 100 km outside Cape Town. A large commercial broiler farm is situated 2 km outside Hopefield, which indicates that the town is located close enough to established broiler markets.

A low throughput abattoir is located in Hopefield. Broiler farmers from as far as Vanrhynsdorp have their broiler produce slaughtered at this abattoir.

The case study involves investigating the current conditions of two small-scale farmers who farm broilers around the outskirts of Hopefield. The goal of the case study is to use the farmers' parameters and inputs and to then determine the theoretical outcomes of the farmers' financial status, using the models as explained in Chapter 3. The model will therefore simulate the financial outputs of small-scale farmers' production and can also be used to compare and analyse different input data, such as using a crossbred chicken genotype.

Both farmers were interviewed simultaneously on a semi-structured basis. They live approximately 800m away from one another and farm with broilers close to and around their houses. Their production practices are similar but their scale of production differs. Their cases are documented below.

Case 1

Background and general management

The farmer farms on an 'all-in-all out' production system. This type of system is recommended and preferred by most farmers and integrators because of the biosecurity risks that are associated with multiple flock production (Permin & Detmer, 2007).

Baumann (2000) found that for most contract farmers in Africa, non-farm income is critical to their livelihood strategy. In the case of this farmer, who farms on an 'all-in-all out' system which does not allow for a monthly income, the farmer makes and sells candles as well as decoupage paintings. He sells his candles via word-of-mouth marketing and his decoupage paintings at a small antique shop in Langebaan, a town nearby.

Production inputs

The farmer purchases A-grade chicks that have been vaccinated against Newcastle Disease from two local hatcheries and pays R4.20 or R3.75 per chick. Ideally, the farmer would purchase 1600 chicks, which would fill his housing capacity, but the number of chicks purchased depends mainly on his available cash in hand at the time.

Housing

The farmer built three of the four houses he owns. He has three houses that are in operating condition, each being 9.5m × 4.2m. His stocking density is 10 birds/m², which therefore allows each house to contain up to 400 birds.

Another two houses is currently under construction which would be able to house 400 birds each. In addition, the farmer plans to build a larger house which would be able to house 1000 birds. The houses are in close proximity to one another and are shown in Figures 11 - 15. According to the farmer, the house in Figure 11 was built through a government grant of R90 000. The farmer is unhappy about the structure of the house and has not yet placed broilers in the house. Figure 12 and Figure 13 are photos of the other two broiler houses which the farmer owns. Figure 14 shows the broiler house under construction.

Figure 11 Broiler house under construction

Figure 12 A Broiler house with plastic side curtains for natural ventilation

All the houses have concrete floors and roll down plastic curtains. The farmer uses tube feeders and bell drinkers. Corrugated iron is used for side walls as well as for the roofs. The side walls are 90cm (see Figure 14, 15) in height and all openings are covered with the usual bonnox or chicken mesh. According to Nyaga (2007), corrugated iron can easiliy be cleaned; however, depending on environmental conditions, it could become very hot in summer and extremely cold in winter.

Figure 13 Broiler houses

Figure 14 Broiler house under construction

The houses have no form of heat insulation. Production in the winter season is uneconomical due to high mortality rates. Consequently, the farmer does not attempt to farm in winter.

Nyaga (2007) states that houses should protect birds from strong winds and also provide enough sunlight. In the case of this farmer, house orientation is taken into account, not according to sunrise and sunset, but according to the prevailing wind, which is usually a South Easterly wind. Therefore the houses are oriented in a North Westerly – South Easterly direction.

The farmer does not use equipment to monitor or control the temperatures and humidity of the broiler houses. Instead, the curtain heights are adjusted to meet the temperature requirements of the birds by observing their behaviour. Figure 15 shows how the structure of the house is supported by wooden poles. This poses a biosecurity threat, because it is difficult to disinfect wood; especially if the wood is not properly treated (Aviagen, 2002).

Figure 15 Side view of a broiler house

Figure 16 Inside of a broiler house

The farmer uses wire and shade netting to create a round spot brooding area inside the house. The shade netting is placed in a circle inside the house. The chicks are kept warm with infrared lighting for the first 14 days. Biosecurity risks involved in all aspects of the farmer's production system are described in the section on biosecurity that follows at a later stage.

Figure 17 Yellow shade netting used for brooding

Water

Municipal water is used for the broiler production. Although there is a borehole on the farm, the water is not used for the broiler drinking system. The farmer believes that the water provided by the municipality is of better quality than that from the borehole. The farmer does not test or treat the water. Figure 18 shows the water tank with connections that lead to all the houses. The entire water system is drained during the cleaning period and rinsed with disinfectant.

Feed

Feed is purchased and collected at the Maize cooperative in Moorreesburg, a town approximately 40 km away. The farmer purchases the feed either on the day it is required, or one or two days prior to need. Standard starter, grower and finisher rations are bought in 50kg bags. The farmer is not registered as a member of the cooperative, but is able to buy feed under a registered farmer's name. This allows him to purchase feed at a discounted price. At the time of the interview, the farmer paid amounts of R190 per bag of starter feed, R210 per bag of grower feed and R180 for a bag of finisher feed.

Figure 18 A water tank connected to all broiler houses

The broilers are fed starter ration for two weeks, grower ration for another two weeks and finisher ration for one week.

The feed is stored in air tight containers (Figure 19). The farmer feeds the food in sized rations so that at the end of a cycle the food is finished. Feed is therefore only stored for the time period that the broilers are feeding off that particular ration. The farmer clearly stated that there is never any feed left over after a production cycle.

Figure 19 Feed storage containers

Feed intake is not monitored. The farmer does not calculate feed conversion ratios or any other feed measurement. The only monitoring measure the farmer takes is the weighing of the broilers at 14 days to ensure that chicks are at approximately the correct weight.

Biosecurity, hygiene and health

A farmer needs to have a sound biosecurity system in place. The biosecurity procedures form part of the general management necessary to farm productively.

The farmer is aware of biosecurity and takes minor precautions against transfer of diseases. Visitors are not allowed to enter the broiler houses unless they wear protective clothing. However, they are not required to make use of foot baths when entering houses.

The farmer owns a flock of backyard poultry and goats (Figure 20). The backyard poultry and goats are located very close to his broiler houses, which could cause diseases to spread from the livestock to the broilers.

Figure 20 Broiler farmer's other livestock

A further concern is the cleaning and hygiene procedures (Aviagen, 2002). The farmer cleans the houses using viral kill or farm fluid detergents. After soaking the surfaces, a high pressure hose is used to remove excess detergents. Thereafter, Jeyes Fluid is spray on the surfaces and the house is left to stand for 10 days before starting a new cycle. All equipment, feed and water lines are also cleaned in the same manner.

Slaughter and Market

The farmer does not farm under a contract. A portion of the produce is sold to an individual who leases an abattoir in Hopefield. They have an informal verbal agreement. The produce is slaughtered utilising a 'kosher' method and sold to a Jewish market in Cape Town. The lessee of the abattoir pays the farmers R19 per chicken and the slaughter cost is covered by the lessee.

Depending on the weight required from the abattoir lessee, the farmer usually slaughters his broilers at 5 weeks, at a weight of approximately 1.5 kg (live weight) per broiler. This is well below the average live weight of 1.8 kg at 5 weeks that is found in commercial operations and this fact would have a substantial impact on FCR and production efficiency.

The farmer also sells produce at local markets, taxi ranks and informal settlements. If the farmer wishes to sell the broilers frozen, the owner of the abattoir charges him a R3.50 slaughter fee per chicken (excluding VAT). The slaughter fee excludes any packaging or cuttings. Once slaughtered, the meat is collected on the next day and the farmer does the cuttings and packaging himself. The farmer owns a large freezer in which the broiler meat is frozen until sold. The freezer is 4 m × 2 m in size. The transport costs to these markets are high and the farmer cannot afford to sell only a percentage of the broilers on the day that the markets are visited. Fortunately, the farmer usually has no difficulty selling his live broilers.

Figure 21 Freezer used by farmer to store broiler meat

Case 2

As stated at the beginning of this chapter, the two farmers have similar production processes. Their marketing strategies are identical in that both farmers sell their broilers to the lessee of the abattoir on an informal basis; sell live or frozen broilers at taxi ranks, informal settlements and local markets. The differences in Farmer 2's production methods are documented.

This farmer is considered the expert in raising broilers among the small-scale broiler farmers in Hopefield. He worked as a broiler house manager for a well established broiler production company in Gauteng.

The farmer has two broiler houses, both are 9 m × 3.3 m each holding 300 birds per house. One house is a wooden house which was converted to a broiler house (Figure 22).

The farmer is aware that the houses' side walls are too high and plans to lower them to 90 cm. Municipal water is used and broods the chicks are brooded under infrared lights.

The wooden house (Figure 22) poses a high threat of bacterial infestation (see Section 2.2.2). The house cannot be cleaned properly and the wood, if left untreated, could carry termites (Aviagen, 2002).

Figure 24 shows the house which the farmer built himself. The left part of the house is a storage area where feed and cleaning detergents are stored.

Farmer 2's houses are also very close to one another. An 'all-in-all out' system is used which increases biosecurity (Permin & Detmer, 2007). The houses are cleaned in the same manner as Farmer 1, but the chicks are brooded in a different way. Figure 23 shows the brooding mechanism constructed by the farmer. The lights are placed through the hanging structure and lowered to approximately 90cm above the chicks.

Figure 22 Broiler wooden house

According to Hobson & Celia (2007), straw is the most common form of bedding used. They also state that shredded newspaper is efficient and does not pose a threat to biosecurity. Newpaper is highly absorbent and contains no parasites. Figure 23 shows that this farmer makes use of newspaper for insulation.

Figure 23 Brooding area with newspaper as insulating material

Figure 24 Brick and mortar broiler house with side curtains and the store room visible

6.4 Parametric Analysis

Visual Basic Programming (VBA) was used to conduct parametric analysis. Macros were built which automatically run through the specified parameters and thereafter present economic results based on parameter intervals included.

Parametric analysis was conducted on parameters that highly influence broiler production outcomes, namely:

- Chick Purchase Price - What is the highest price that the small-scale farmer can afford to pay for day old chicks?
- Feed Prices - As mentioned earlier, feed is the highest operating cost of a broiler production. An analysis of feed prices clearly indicates the effect the feed price has on the profitability of the farm. Furthermore, feed prices are extremely volatile and can seriously jeopardise the production if the farmer has no cash on hand to pay for feed.
  The last reason for analysing the cost of feed is to create “what if” scenarios, such us: What if the feed is fully or partially subsidised by government?
- Selling Price per kg Broiler Meat - What price per kg broiler meat should the small-scale farmer get paid to at least break even?

The analysis is conducted on all modelled scenarios. Results on data analysis, models and discussions follow in the next chapter.

7 Results and Discussion

Results are presented in the same order as the data collection procedures in the previous chapter. A discussion regarding the results and findings are presented for each scenario.

7.1 Base Model Results

The initial investment for the three different scales of production is given in Table 7, together with their associated NPV. A commercial broiler genotype's input parameters were used for the base model scenario.

From Table 7 it is apparent that the 1500-sized broiler production has the largest NPV. The large negative NPV for the 2500-sized broiler production is caused by the much larger investment cost. The base model assumes that farmers produce throughout the year and that performance is not influenced by change in seasons.

Table 7 Base model scenario

Scale of Production	500 Birds/Cycle	1500 Birds/Cycle	2500 Birds/Cycle
Initial Investment	R93 820.00	R187 860.00	R374 090.00
Chick Purchase Price	R3.75	R3.75	R3.75
Selling Price per kg broiler meat	R16.24	R16.24	R16.24
NPV	R -398916.00	R -173372.00	R -521896.00

At these investment costs, even if farmers obtain commercial production specifications, include mortality margins and revenue and have similar capital costs, it is not feasible to farm with broilers on a scale of 500, 1500 or 2500 birds per cycle.

7.1.1 Parametric Analysis

Parametric analysis was conducted separately on each scale of production. Selling prices, chick purchase prices and feed prices were analysed. Note: All analysis was conducted over a 10 year period.

Varying Selling Price, Chick Purchase Price and Feed Cost

Both parameters were varied so that we could gain an idea of what effect the parameters have on the net present value.

500 Birds/Cycle

Table 8 shows the various net present values obtained with the corresponding parameters. The red entries show the maximum and minimum NPV's that could be obtained (applies to Table 8, 10 and 12). At the extreme of obtaining R20/kg for broiler meat and purchasing chicks for only R3, the net present value still remains below zero, concluding that based on the selling price for broiler meat and chick prices, a scale of production of 500 birds per cycle is uneconomical even if R20/kg is obtained.

Table 8 NPV with varying selling price/kg and chick purchase price – 500 Birds/Cycle

Estimated Price Return per kg Broiler Meat	Chick Purchase Price			
	R3.00	**R3.67**	**R4.33**	**R5.00**
R15.00	R -428 090.73	R -452 101.30	R -476 111.86	R -500 122.42
R16.67	R -352 572.36	R -376 582.92	R -400 593.49	R -424 604.05
R18.33	R -277 053.99	R -301 064.55	R -325 075.11	R -349 085.68
R20.00	R -201 535.62	R -225 546.18	R -249 556.74	R -273 567.30

Next, the influence of discounted feed prices was investigated. Feed prices were discounted at 5%, 10% and 15%. Table 9 presents the associated NPV's. The outcomes showed that even with decreasing the highest operating cost (feed) associated with broiler production, a production scale of 500 birds per cycle is not feasible.

Table 9 NPV with discounted feed prices – 500 Birds/Cycle

Cost/50kg Bag	0% Discount	5% Discount	10% Discount	15% Discount
NPV	R -398 916.00	R -378 067.00	R -357 280.00	R -336 429.00

1500 Birds/Cycle

Table 10 shows the various net present values obtained with the corresponding parameters. At the extreme of obtaining R20/kg for broiler meat and purchasing chicks for only R3, the net present value is R 41 805 79.34. Table 10 indicates that positive NPV's are attainable. However, the NPV remains low, especially considering that the analysis was conducted over a 10 year period.

Table 10 NPV with varying selling price/kg and chick purchase price with 1500 Birds/Cycle

Estimated Price Return per kg Broiler Meat	Chick Purchase Price			
	R3.00	**R3.67**	**R4.33**	**R5.00**
R15.00	R -260 830.00	R -332 861.68	R -404 893.36	R -476 925.05
R16.67	R -34 360.22	R -106 391.90	R -178 423.58	R -250 455.27
R18.33	R 192 109.56	R 120 077.88	R 48 046.20	R -23 985.48
R20.00	R 418 579.34	R 346 547.66	R 274 515.98	R 202 484.30

Next, the influence of discounted feed prices was investigated. Feed prices were discounted at 5%, 10% and 15%. Table 11 presents the associated NPV's. Table 11 shows that with a 15% discount on feed, a positive NPV is attainable. Once again, the NPV value is very small if it is taken into account that the analysis was taken over a period of 10 years. The corresponding IRR value was 9%.

Table 11 NPV with discounted feed prices with 1500 Birds/Cycle

Cost/50kg Bag	0% Discount	5% Discount	10% Discount	15% Discount
NPV	R -173 372.12	R -110 846.41	R -485 09.42	R 140 18.73

2500 Birds/Cycle

Table 12 shows the various net present values obtained with the corresponding parameters. At the extreme of obtaining R20/kg for broiler meat and purchasing chicks for only R3, the net present value is R464 624.77. Table 12 indicates that positive NPV are attainable, however, the NPV remains relatively low, especially considering that the analysis is conducted over a 10 year period.

Table 12 NPV with varying selling price/kg and chick purchase price – 2500 Birds/Cycle

Estimated Price Return per kg Broiler Meat	Chick Purchase Price			
	R3.00	**R3.67**	**R4.33**	**R5.00**
R15.00	R -667 638.81	R -787 691.61	R -907 744.42	R -1 027 797.22
R16.67	R -290 217.62	R -410 270.42	R -530 323.23	R -650 376.03
R18.33	R 87 203.57	R -32 849.23	R -152 902.03	R -272 954.84
R20.00	R 464 624.77	R 344 571.96	R 224 519.16	R 104 466.35

Next, the influence of discounted feed prices was investigated. Feed prices were discounted at 5%, 10% and 15%. Table 13 presents the associated NPV's. Table 13 shows that even with a 15% discount on feed, the outcomes are still uneconomical.

Table 13 NPV with discounted feed prices –2500 Birds/Cycle

Cost/50kg Bag	0% Discount	5% Discount	10% Discount	15% Discount
NPV	R-521 896.85	R -417 695.18	R -313 808.03	R -209 602.28

Varying Selling Price of the Broiler Meat

The effect on the NPV at year 10 when varying the selling price of broiler meat from R15 to R30 is shown in Figures 25, 26 and 27. From this analysis it is also easily established which scale of production is the most feasible when analysed according to break even selling prices.

The relationship between NPV and selling price is linear in the model (Figures 25, 26 and 17). Through interpolation the break even selling price is calculated as R25.05, R17.51 and R18.54, respectively.

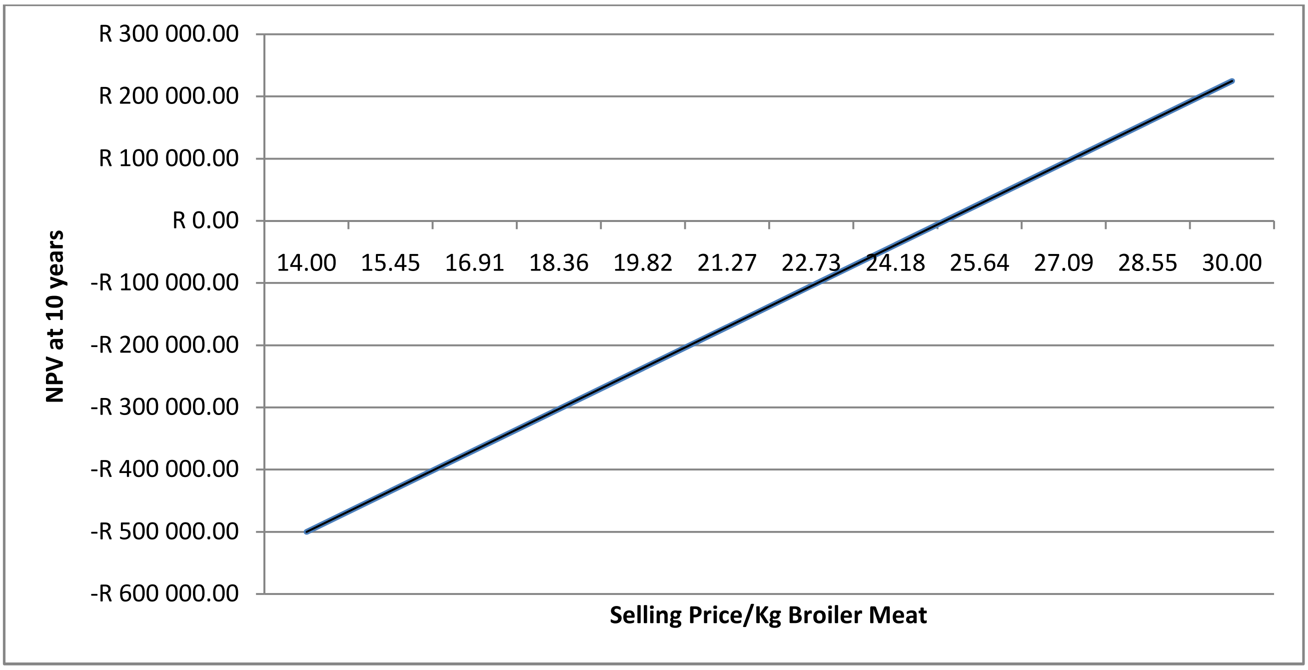

Figure 25 NPV of a 500 Birds/Cycle scale of production with varying selling price

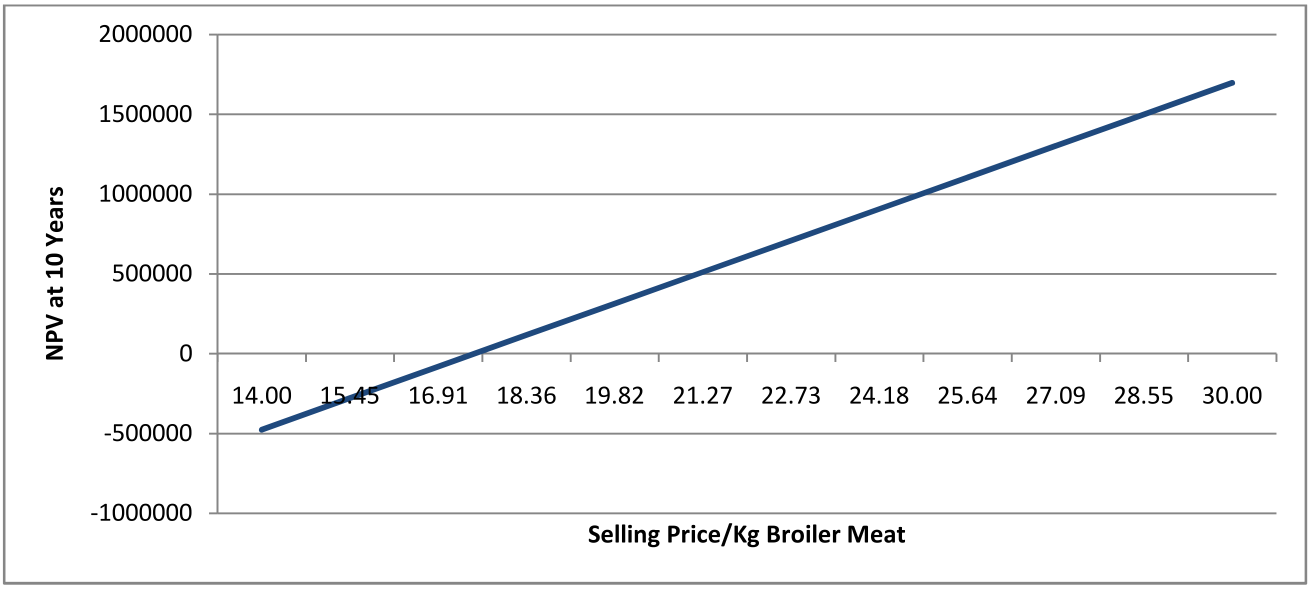

Figure 26 NPV of a 1500 Birds/Cycle scale of production with varying selling price

Table 14 tabulates the above varying selling price values and their associated NPV's while Table 15 summarises the break even selling prices. The highlighted values indicate the intervals between which the break even selling prices occur.

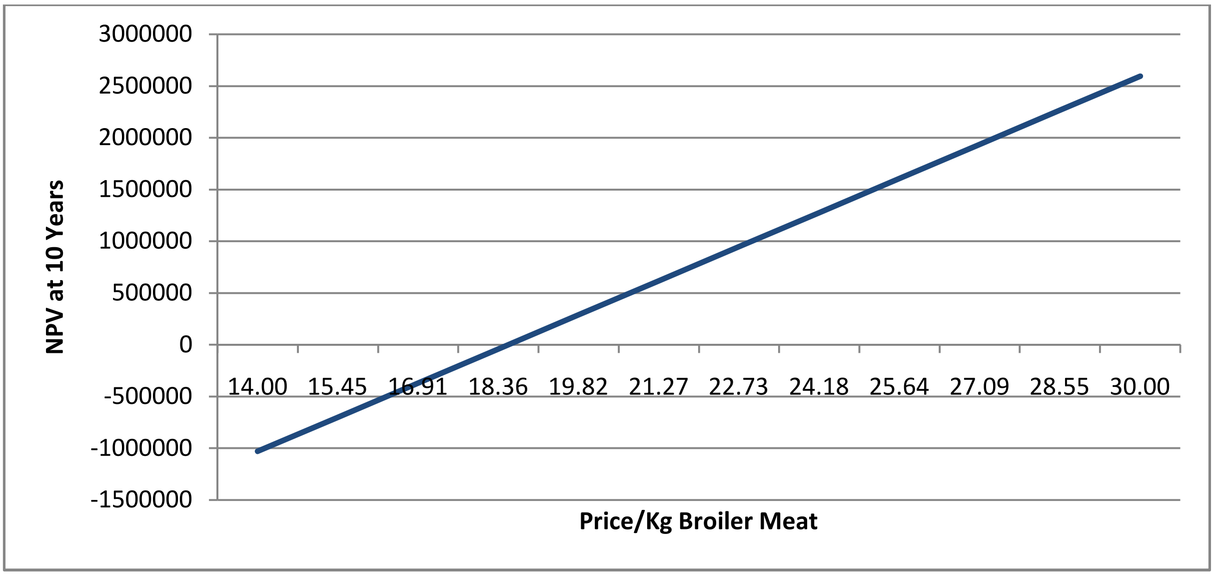

Figure 27 NPV of a 2500 Birds/Cycle scale of production with varying selling price

Table 14 NPV over varying selling prices

Selling Price per kg Broiler Meat	Production Size		
	500 Birds/Cycle	**1500 Birds/Cycle**	**2500 Birds /Cycle**
R14.00	-R 500 413.64	-R 477 747.51	R -1029 150.93
R15.45	-R 434 506.70	-R 280 101.16	R -699 765.16
R16.91	-R 368 599.75	-R 82 454.8	R -370 379.39
R18.36	-R 302 692.81	R 115 191.55	R -40 993.63
R19.82	-R 236 785.87	R 312 837.91	R 288 392.14
R21.27	-R 170 878.93	R 510 484.26	R 617 777.91
R22.73	-R 104 971.99	R 708 130.62	R 947 163.68
R24.18	-R 39 065.05	R 905 776.97	R 1276 549.44
R25.64	R 26 841.90	R 1103 423.33	R 1605 935.21
R27.09	R 92 748.84	R 1301 069.68	R 1935 320.98
R28.55	R 158 655.78	R 1498 716.03	R 2264 706.74
R30.00	R 224 562.72	R 1696 362.39	R 2594 092.51

Table 15 Summary of base model selling price break evens

Scale of Production	**500 Birds/Cycle**	**1500 Birds/Cycle**	**2500 Birds/Cycle**
Break Even Selling Prices	R25.05	R17.51	R18.54

7.1.2 Findings and Discussion: Base Model

The purpose of the base model was to gain an idea of what a contract farmer could expect if farmers received commercial remuneration and adhered to commercial standards. Although small-scale farmers would most probably not be able to achieve commercial production standards, the model could be seen as a "best case scenario".

From the base model results, it was concluded that only the 1500 and 2500 scale of production is worth further investigation. As stated in the previous chapter, net present values are not sufficient if one compares mutually exclusive scenarios (i.e. different scales of production). However, due to large negative net present values, IRR's could not be compared.

The base model clearly showed that based on commercial data, the 1500 scale of production is the most favourable. However, the investigation is based on break even analysis; both 1500 and 2500 scales of production could break even over 10 years, with relatively small selling prices compared to that of the 500 scale of production.

Table 14 showed that if the selling price per kg broiler meat was R30 and the scale of production was 2500 birds/cycle; the net present value would be R 2 594 092.51. Although a R30 return per kg broiler meat is highly unlikely in an intensive production system, it may be viable in the free-range production system. Furthermore, the large initial investment cost of a free-range system is not as high as that of an intensive system. Therefore, the conclusion is that although an intensive system is uneconomical, a free-range production system may present higher returns.

7.2 Comparing Performance Traits between Progeny of 3 Genotypes

Performance traits on the progeny of 3 genotypes, namely: the Hybro hens X Cobb500 roosters (HC), pure indigenous Potchefstroom Koekoek (KK) and a cross between indigenous Potchefstroom Koekoek hens and commercial Ross 308 (KR) roosters were compared. The data results include means, standards deviations and standard errors and level of confidence intervals of parameters. Data is tabulated and each treatment's statistics are presented. Treatment 1 refers to the Hybro X Cobb500 broilers genotype, treatment 2 refers to the Ross 308 X Potchefstroom Koekoek genotype and treatment 3 to the Potchefstroom Koekoek.

7.2.1 Growth Performance

From Table 16 it is seen that the HC, KR and KK had an average mean weight of 2269.75g, 2021.43g and 1317.01g, respectively. Live slaughter body weights (BW) were higher (P<0.01) in the HC genotype than the KK or KR genotype. The KR body weights were higher (P<0.01) compared to the KK genotype.

Table 16 Average body weights of treatments at slaughter age

Treatment	Avg chick weight (g) Mean	Avg chick weight Std.Err.	Avg chick weight -95.00%	Avg chick weight +95.00%	N
HC[1]	2269.75[a]	30.67	2205.56	2333.94	8
KR[2]	2021.43[b]	35.41	1947.31	2095.55	6
KK[3]	1317.01[c]	30.67	1252.82	1381.20	8

[(a, b, c)] Values with different superscripts within columns differed significantly (P<0.05)

[(1)] Cobb500 males X Hybro G females

[(2)] Ross308 males X Potchefstroom Koekoek females

[(3)] Potchefstroom Koekoek

Figure 28 shows the comparison of growth curves for each genotype. Growth curve functions are the most adequate means for describing the growth patterns of body weight. The most commonly used growth functions are Brody's, Logistic, Gompertz, von Bertalanfy and the Richard function (Fritzhugh, 1976; Knizetova *et al*., 1991).

The growth model used for the three genotypes is shown in Equation 13 (StatSoft Inc, 2009).

$$v7 = B + (T - B)/(1 + 10^{(EC50 - v3)*S)}) \tag{13}$$

In this case, the non-linear mathematical equations for each genotype HC, KR and KK are presented in Equation 14, 15 and 16 respectively. As can be seen from the R^2, the model used had a good fit on the data.

$$y = (-321.52) + ((5457.36) - (-321.52))/(1 + 10^{((45.4392) - x)*(.0297925)})) \tag{14}$$
$$[R^2 = 1]$$

$$y = (-78.599) + ((2403.93) - (-78.599))/(1 + 10^{((41.8697)-x)*(.037466)}) \quad [R^2 = 0.99] \tag{15}$$

$$y = (-160.8) + ((1872.91) - (-160.8))/(1 + 10^{((57.1747)-x)*(.01986)}) \quad [R^2 = 0.99] \tag{16}$$

In the above equations 14, 15 and 16, y refers to the average cumulative gain per chick and x refers to the day number. Figures 29, 30 and 31 illustrate the growth curve of each treatment.

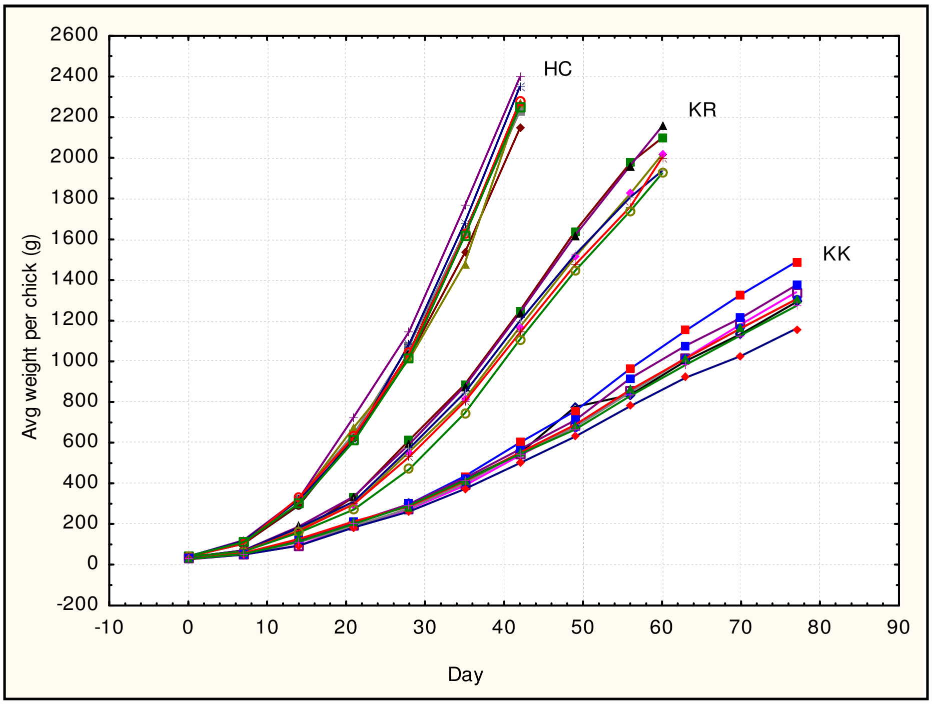

Figure 28 Growth curves of three genotypes from day 0 to the respective slaughter age: Cobb500 males X Hybro G females (HC); Ross308 males X Potchefstroom Koekoek females (KR); Potchefstroom Koekoek (KK)

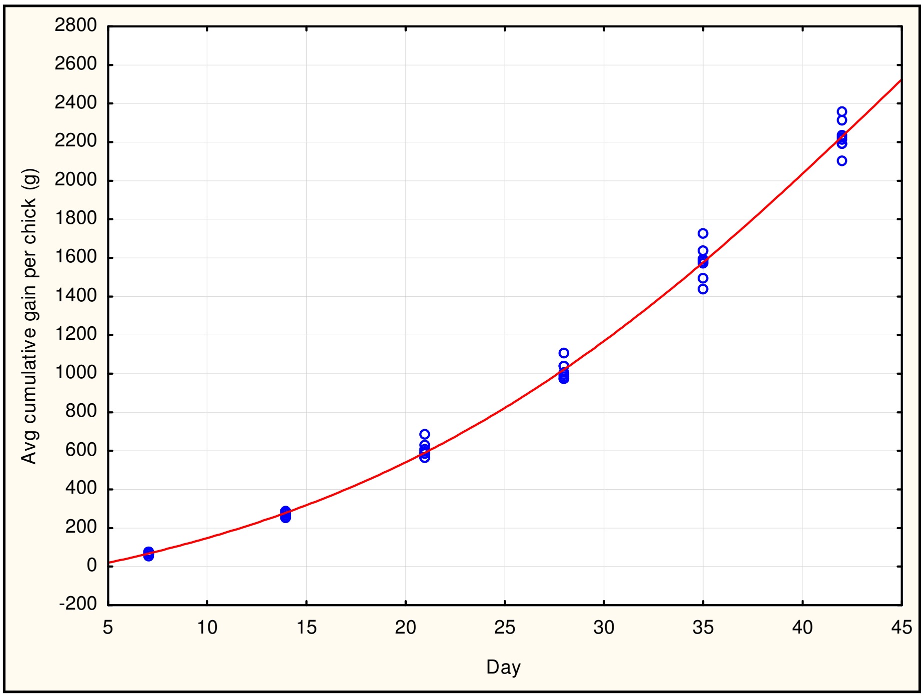

Figure 29 Cobb500 males X Hybro G females (HC) growth curve from day 0 to the slaughter age of 42 days

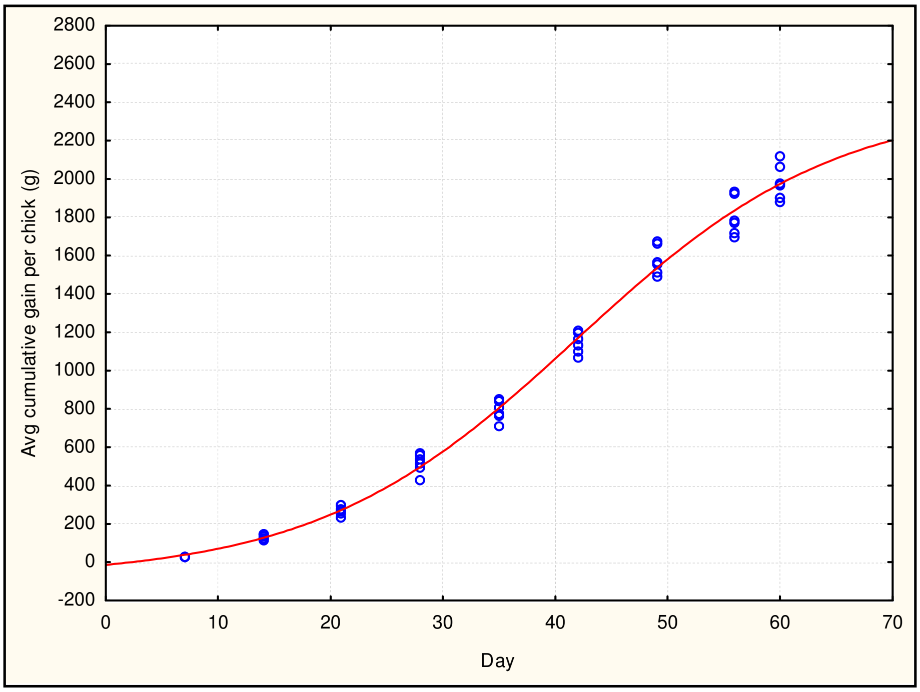

Figure 30 Ross308 males X Potchefstroom Koekoek females (KR) growth curve from day 0 to the slaughter age of 60 days

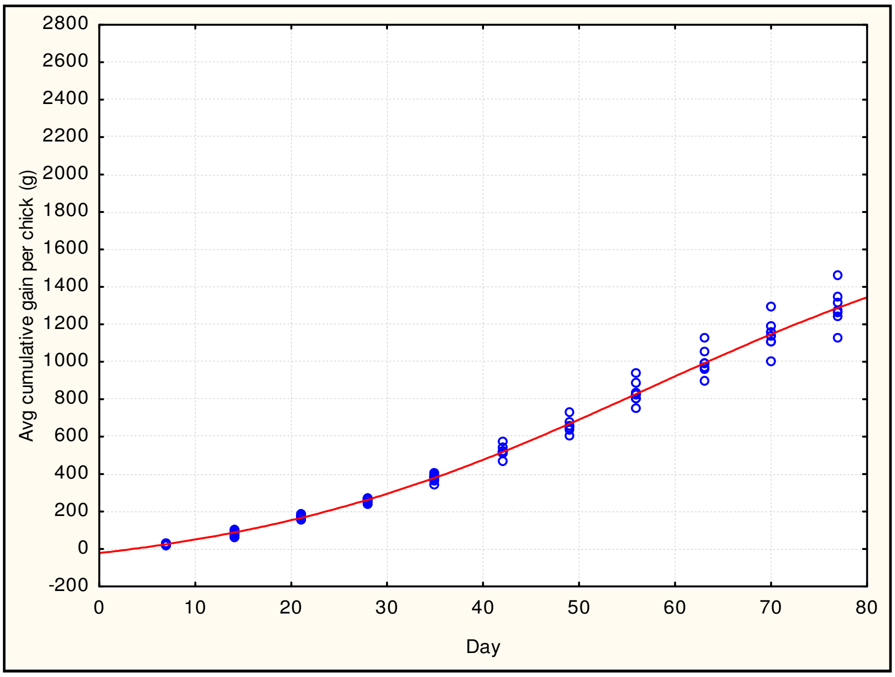

Figure 31 Potchefstroom Koekoek (KK) growth curve from day 0 to the slaughter age of 77 days

7.2.2 Feed Utilization Efficiency

Bearing in mind that genotypes were slaughtered at different ages and different weights, interesting results were obtained for the feed intake per genotype. There were highly significant (P<0.05) differences in feed intake between the genotypes. At slaughter age, the cumulative feed intakes of the HC, KR and KK genotypes were 4046.02 g (42 days), 4252.05 g (60 days), 3983.87 g (77 days) per bird, respectively (Table 17). HC and KK did not show a significant difference in feed intake (P=0.606). However, the KR genotype showed that there was a significant difference in feed intake compared to both the HC (P=0.0499) and the KK (P=0.0499) genotypes. The KR chicks thus had a higher intake than the KK genotype, but consumed only 206.03 g more feed than the HC genotype despite the fact that they were reared for an additional 18 days past the slaughter age of the HC broiler genotype.

Table 17 Average cumulative feed intake per genotype

Treatment	Cumulative Feed Intake per Chick Mean	Cumulative Feed Intake per Chick Std.Dev.	Cumulative Feed Intake per Chick Std.Err	Cumulative Feed Intake per Chick - 95.00%	Cumulative Feed Intake per Chick +95.00%
HC[1]	4046.02 [b]	244.46	86.43	3841.65	4250.40
KR[2]	4252.05 [a]	304.23	124.20	3932.79	4571.32
KK[3]	3983.87 [b]	163.66	57.86	3847.05	4120.70

[(a, b, c)] Values with different superscripts within columns differed significantly (P<0.05)

[(1)] Cobb500 males X Hybro G females

[(2)] Ross308 males X Potchefstroom Koekoek females

[(3)] Potchefstroom Koekoek

Feed efficiency was expressed as FCR. Feed conversion ratios of all genotypes were significantly different (P<0.01) (Table 18). The HC broilers had the lowest FCR (1.78) and were the most efficient in terms of amount of feed consumed in relation to weight gained. The KR was the second most efficient (2.1) and the KK least efficient (3.03).

Figure 32 illustrates the comparison of feed intake per genotype across a time period. From this graph it is clear that the HC consumed the most feed in the shortest period of time. However, the cumulative intake of the HR was higher than that of the HC.

Table 18 Average feed conversion ratios for three different genotypes

Treatment	FCR - Mean	FCR - Std.Dev.	FCR - Std.Err	FCR -95.00%	FCR +95.00%
HC[1]	1.78[a]	0.06	0.02	1.73	1.83
KR[2]	2.11[b]	0.18	0.07	1.92	2.30
KK[3]	3.04[c]	0.26	0.09	2.81	3.26

[(a, b, c)] Values with different superscripts within columns differed significantly (P<0.05)

[(1)] Cobb500 males X Hybro G females

[(2)] Ross308 males X Potchefstroom Koekoek females

[(3)] Potchefstroom Koekoek

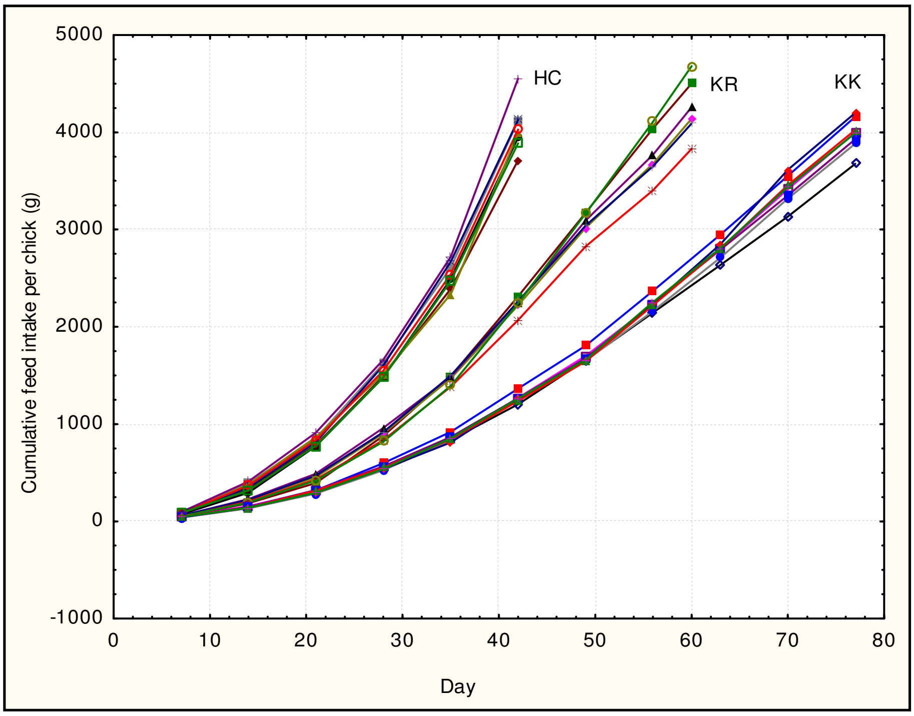

Figure 32 Cumulative feed intake of three genotypes: Cobb500 males X Hybro G females (HC); Ross308 males X Potchefstroom Koekoek females (KR); Potchefstroom Koekoek (KK)

7.2.3 Mortality

There were no significant differences between genotypes in mortalities (Table 19). Most mortalities occurred in the first week. No mortalities were found in the cross genotype (KR). The main reason for fatalities in the KK genotype was due to weak chicks which were presumably runts. One instance of Black Naval Disease was found in the KK genotype. The mortalities which occurred in the HC genotype were primarily caused by general lung infections and leg diseases.

Table 19 Liveability per genotype

Treatment	% Liveability Mean	% Liveability Std.Dev.	% Liveability Std.Err	% Liveability - 95.00%	% Liveability +95.00%
HC[1]	0.94[a]	0.09	0.03	0.86	1.02
KR[2]	1.00[a]	0.00	0.00	1.00	1.00
KK[3]	0.95[a]	0.07	0.02	0.90	1.01

(a, b, c) Values with different superscripts within columns differed significantly (P<0.05)

(1) Cobb500 males X Hybro G females

(2) Ross308 males X Potchefstroom Koekoek females

(3) Potchefstroom Koekoek

7.2.4 European Efficiency Production Factor

The EPEF was used to compare the different treatments with respect to overall performance (Table 20). There were significant differences (P<0.01) in EPEF among the genotypes. The HC had the highest EPEF, which meant highest efficiency (see Section 6.2). From this data it is clear that the KK is highly insufficient compared to the other two genotypes in this trial.

Table 20 European efficiency production factor per genotype

Treatment	EEF - Mean	EPEF - Std.Dev.	EPEF - Std.Err	EPEF -95.00%	EPEF +95.00%
HC[1]	284.79[a]	32.94	11.65	257.25	312.33
KR[2]	161.07[b]	17.50	7.14	142.71	179.44
KK[3]	54.16[c]	7.87	2.78	47.58	60.73

(a, b, c) Values with different superscripts within columns differed significantly (P<0.05)

(1) Cobb500 males X Hybro G females

(2) Ross308 males X Potchefstroom Koekoek females

(3) Potchefstroom Koekoek

It was concluded that the HC broilers performed better in an intensive production system compared to the KR and KK, having a better FCR and the highest production efficiency factor. Feed efficiency is enhanced when chickens are produced in an intensive system compared to a free-range system. It is recommended that the same experiment be repeated on a free-range system to gather information about the KR genotype compared to the KK and HC in such an environment.

7.3 Model Results: Comparing Economic Performance on Genotypes

The base model of the 1500 scale of production was used to evaluate the different broiler genotypes in an intensive production system. Economic performance indicators were calculated using means obtained from the data and standard market prices for remuneration purposes.

The aim was to investigate the difference in the biophysical components of the genotypes. Therefore, variable costs for each genotype were compared.

Table 21 presents the biophysical parameters obtained from the statistical data. Dressing % was taken from Kokoszynski and Bernacki (2008).

Table 21 Biophysical parameters of experimental data obtained

Treatment	Day of Slaughter	Weight (kg)	FCR	Liveability %	EEF
HC[1]	42	2.27	1.78	0.94	284.79
KR[2]	60	2.02	2.11	1.00	161.07
KK[3]	77	1.32	3.04	0.95	54.16

(1) Cobb500 males X Hybro G females

(2) Ross308 males X Potchefstroom Koekoek females

(3) Potchefstroom Koekoek

Table 22 presents the associated fixed and variable cost per genotype. From Table 22 it is clear that variable costs are relatively close to each other. Although there were significant differences between the genotypes in terms of cumulative feed intake (P>0.05), variable costs are similar due to difference in the mortality rates of genotypes.

Large differences are apparent in the fixed cost per broiler (Table 22). The longer cycle time of the Potchefstroom Koekoek clearly affects the fixed cost. Costs such as depreciation, insurance and labour are higher for the KR and KK genotypes because of their longer cycle times.

Table 22 NPV and variable cost comparison of experimental treatments

Treatment	Variable Cost/Bird	Fixed Cost/Bird
HC[1]	R 21.12	R 3.11
KR[2]	R 20.52	R4.91
KK[3]	R 20.88	R5.08

(1) Cobb500 males X Hybro G females

(2) Ross308 males X Potchefstroom Koekoek females

(3) Potchefstroom Koekoek

NPV over varying Mortality Rate

The effect of mortality rates on NPV's are investigated and shown in Table 23.

For both the cross and indigenous breeds, even in the best case scenario of a zero mortality rate, the outcomes are infeasible over a 10 year period.

Up to this point, all the results used market valued revenue per kg broiler meat. Therefore, break even points were determined to establish what price a farmer should earn at minimum.

Table 23 Effect of mortality rates on NPV

Treatment	Experimental rates	0%	5%	10%	15%
HC[1]	R 252 587.20	R 400 330.71	R 278 847.22	R 152 278.62	R 25 837.31
KR[2]	-R 31 271.86	-R 31 271.86	-R 115 112.03	-R 195 085.95	-R 275 367.99
KK[3]	-R 533 884.49	-R 492 039.02	-R 533 884.49	-R 576 660.59	-R 618 122.47

(1) Cobb500 males X Hybro G females

(2) Ross308 males X Potchefstroom Koekoek females

(3) Potchefstroom Koekoek

Break Even Selling Prices

Tables 24, 25 and 26 present break even selling prices for HC, KR, and KK respectively. The grey highlighted areas indicate positive NPV's at the corresponding chick prices and selling prices.

Table 24 Commercial HC break even over various selling prices and chick purchase prices for a 1500 scale of production

Selling price per kg chicken meat	Chick Purchase Price		
	R 3.00	R 4.00	R 5.00
R 12.00	R -284 226.32	R -378 108.58	R -471 990.85
R 14.55	R 80 323.63	R -13 558.63	R -107 440.90
R 17.09	R 444 859.26	R 350 977.00	R 257 094.73
R 19.64	R 809 409.21	R 715 526.95	R 621 644.68
R 22.18	R 1 173 944.84	R 1 080 062.58	R 986 180.31
R 24.73	R 1 538 494.79	R 1 444 612.53	R 1 350 730.26
R 27.27	R 1 903 030.42	R 1 809 148.16	R 1 715 265.89
R 29.82	R 2 267 580.37	R 2 173 698.11	R 2 079 815.84
R 32.36	R 2 632 116.00	R 2 538 233.74	R 2 444 351.47
R 34.91	R 2 996 665.95	R 2 902 783.69	R 2 808 901.42
R 37.45	R 3 361 201.58	R 3 267 319.32	R 3 173 437.05
R 40.00	R 3 725 751.53	R 3 631 869.27	R 3 537 987.00

Table 25 KR break even over various selling prices and chick purchase prices for a 1500 scale of production

Selling price per kg chicken meat	Chick Purchase Price		
	R 3.00	R 4.00	R 5.00
R 12.00	-R 403 220.46	-R 473 015.25	-R 542 810.03
R 14.55	-R 148 493.54	-R 218 288.33	-R 288 083.11
R 17.09	R 106 223.37	R 36 428.59	-R 33 366.20
R 19.64	R 360 950.29	R 291 155.51	R 221 360.73
R 22.18	R 615 667.21	R 545 872.42	R 476 077.64
R 24.73	R 870 394.13	R 800 599.34	R 730 804.56
R 27.27	R 1 125 111.04	R 1 055 316.26	R 985 521.47
R 29.82	R 1 379 837.96	R 1 310 043.18	R 1 240 248.40
R 32.36	R 1 634 554.88	R 1 564 760.09	R 1 494 965.31
R 34.91	R 1 889 281.80	R 1 819 487.01	R 1 749 692.23
R 37.45	R 2 143 998.71	R 2 074 203.93	R 2 004 409.15
R 40.00	R 2 398 725.63	R 2 328 930.85	R 2 259 136.07

Table 26 KK break even over various selling prices and chick purchase prices for a 1500 scale of production

Selling price per kg chicken meat	Chick Purchase Price		
	R 3.00	R 4.00	R 5.00
R 12.00	-R 703 315.49	-R 758 666.46	-R 814 017.43
R 14.55	-R 576 674.33	-R 632 025.30	-R 687 376.27
R 17.09	-R 450 038.14	-R 505 389.11	-R 560 740.08
R 19.64	-R 323 396.97	-R 378 747.95	-R 434 098.92
R 22.18	-R 196 760.79	-R 252 111.76	-R 307 462.73
R 24.73	-R 70 119.62	-R 125 470.59	-R 180 821.57
R 27.27	R 56 516.56	R 1 165.59	-R 54 185.38
R 29.82	R 183 157.73	R 127 806.76	R 72 455.79
R 32.36	R 309 793.91	R 254 442.94	R 199 091.97
R 34.91	R 436 435.08	R 381 084.11	R 325 733.14
R 37.45	R 563 071.26	R 507 720.29	R 452 369.32
R 40.00	R 689 712.43	R 634 361.46	R 579 010.49

Table 27 presents the break even points of selling prices across 3 different chick purchase prices. These break evens can be compared and used to make a decision as to which genotype is the most economical. From Table 27 it is clear that at a R3.00 chick purchase price, the farmer needs to sell his HC meat for at least R13.99/kg, his KR for at least R 16.03/kg and his KK meat for at least R26.14/kg.

Different production systems could be investigated to gather information about attainable prices, for instance, in a free-range production system. In such a system broiler meat is sold at higher prices. Capital costs are also lower and will therefore decrease the fixed costs associated with the production. Furthermore, a cross broiler may perform better in such a system, because it more likely to adapt better in less optimised environmental conditions.

Table 27 Selling price break evens across chick purchase prices of R3.00, R4.00, and R5.00.

	HC			**KR**			**KK**		
Chick Purchase Price	R3.00	R4.00	R5.00	R3.00	R4.00	R5.00	R3.00	R4.00	R5.00
Selling Price per kg Broiler Meat	R13.99	R 14.64	R15.30	R16.03	R16.73	R17.38	R26.14	R27.24	R28.36

The model indicates that the commercial broiler is the most economical. This was not a surprising outcome as HC are genetically selected over years for low FCR and high growth rates. The important comparison was that of variable costs and break evens. It should be borne in mind that the variables costs are very similar, especially taking into account the large difference in cycle periods. This means that the direct cost of raising any one of the genotype birds will cost the farmer approximately the same.

On the other hand, a large difference in fixed costs is present. This is due to vast difference in cycle period. Finally, a 10 year prediction gives us an indication of whether the overall production investment is worthwhile or not. Together with break evens, the analysis provides insight into profits and necessary break evens.

7.4 Case Study Results

As mentioned in Section 6.3, production processes, infrastructure, market structure, supply and demand procedures were similar for both farmers. Farmer 1 was investigated; capital costs are excluded from this investigation and only cash flows are investigated. All payments occur on the last day of a production cycle.

A cash flow provides an estimate of borrowing requirements and repayment capacity and scheduling. Because start up cash is not known, these values serve as an estimate of cash required at certain periods of time.

Scenario 1

Scenario 1 is based on the farmer's current inputs and outputs if the farmer farms at full capacity. Flock profile inputs are available in Appendix B, Table 33. Furthermore, this scenario does not include winter months; therefore, the farmer has 6.08 production cycles per year.

Table 28 shows how dramatically the income rises and falls over the 10 year period. The explanation for this strange occurrence is due to cycles that start shortly before the end of a particular year, while the cycle's revenues are gathered in the following year. This occurs when a cycle runs over the month of December.

From Table 28 it is clear that the farmer will have a positive cash flow only after year 7, which indicates that the farmer should either have a large amount of cash available prior to production, or be able to borrow cash in order for him to start producing broilers.

Scenario 2

The second scenario describes the farmer's production outcomes if he were able to farm with commercial broilers throughout the time of winter conditions. The flock's profile inputs are available in Appendix C, Table 34.

Table 29 presents the cash flow if the farmer were able to produce throughout the winter months. The increase in cash flow is much higher over 10 years, compared to Scenario 1. If net cash flow (NCF) values are compared (for instance in year 7, scenario 1 = R4017 vs. scenario 2 = R32 667), it is clear that producing over winter months results in a vast improvement in the farmer's cash flow.

An important point to take into account is that the farmer pays his expenses on a daily and monthly basis. Therefore, the NCF may be positive on a yearly basis, but is not necessarily positive on a monthly or daily basis. A monthly cash flow was investigated.

Table 30 presents the cash flow for the first month of the first year's production. From Table 30, it is clear that the monthly NCF is volatile. The reason for the volatile cash flow is primarily due to the three different feed rations which are paid for at different times of the production cycle.

Feed is the largest variable cost of production. As mentioned in Section 6.3, the farmer pays for each feed ration (starter feed, grower feed and finisher feed) 0-2 days prior to it being required. Figure 33 illustrates the resultant volatility of feed cost payments that is due to the three different time periods over which payments are made in a production cycle.

From Figure 33, it is clear that in the second month (February), the feed cost is very low (R5534.12) compared to the other months. In February, the broiler house stood open due to a cleaning period and broilers were only placed on the 15th of February. Therefore, the starter ration was the only feed expense paid for in February. Grower and finisher rations were only bought in month 3 (March). The scheduling of two month's feed ration payments is available in Appendix C, Table 35.

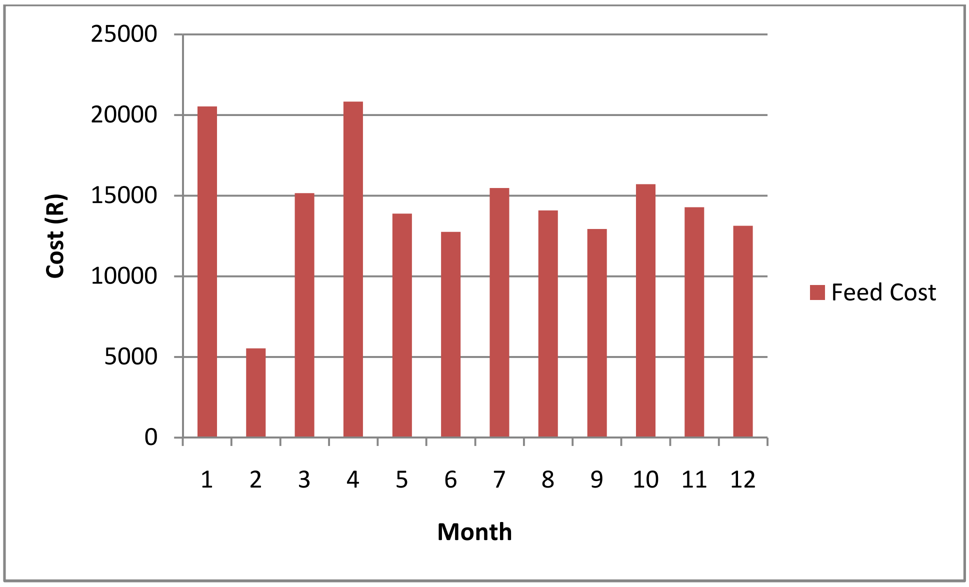

Figure 33 Year 1: Cost of feed for scenario 2

The impact of the feed cost is also easily seen on Table 29, where the income rises from minus R2510.00 in year 1, to plus R10 228.00 in year 2.

Scenario 3

In this scenario, the performance traits of the cross genotype were used to establish the cash flow if production took place throughout the year (Table 31). The cross genotype's flock profile inputs are available in Appendix D, Table 36.

From Table 31 it is clear that in Year 5 the farmer's income drops significantly compared to the previous year's rise in income. A schedule of the farmer's production cycles is presented in Appendix D. Table 37 gives a summary of the number of placements and slaughtering that occur in each year. Table 38 shows the detailed schedules for all placements and slaughter dates for the 10 year detailed period.

Scenario 4

The last scenario investigates varying the selling prices based on commercial remuneration standards when producing crossbred chickens throughout the year. Flock profile inputs are available in Appendix E, Table 39.

Table 32 presents cash flows over a 10 year period at different selling prices when producing crossbred chickens. It is clear that the farmer will have a positive cash flow if chicken meat is sold for

R18.00/kg. At a selling price of either R15.00 or R16.24/kg, the farmer would have substantially negative cash flows. However, at a selling price of R23.58/kg, the farmer would have a positive cash flow of R65 275 cash at the end of the first year.

Results obtained from the case study serve as a basis for further research. It is especially important to consider the possibility of free-range production systems, as best outcomes were obtained through increasing the selling prices. Premium prices are paid for free-range chicken meat, which may result in high profits for the farmer. The cross genotype should be investigated under such environments and performance traits should be established. Thereafter, economic outcomes should be determined and compared to those of intensive production systems.

Table 28 Scenario 1: "AS-IS" scenario (R12.67/kg liveweight)

Cash Flow	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Starting Cash flow	R 0	-R 12 292	-R 12 376	-R 22 896	-R 24 445	-R 26 109	-R 38 596	R 4 017	R 6 611	R 9 397
Income	-R 5 113	R 7 471	-R 1 703	R 7 812	R 8 274	-R 1 051	R 51 280	R 11 735	R 12 429	R 13 164
Expenses	R 6 163	R 6 533	R 6 926	R 7 342	R 7 782	R 8 249	R 8 746	R 9 271	R 9 827	R 10 416
PBIT	-R 11 277	-R 11 354	-R 21 006	-R 22 426	-R 23 953	-R 35 409	R 3 939	R 6 482	R 9 213	R 12 145
Interest	-R 1 015	-R 1 022	-R 1 891	-R 2 018	-R 2 156	-R 3 187	R 79	R 130	R 184	R 243
Net Cash Flow	-R 12 292	-R 12 376	-R 22 896	-R 24 445	-R 26 109	-R 38 596	R 4 017	R 6 611	R 9 397	R 12 388

Table 29 Scenario 2: Including winter months (R12.67/kg live meat)

Cash Flow	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Starting Cash flow	R 0	-R 9 454	-R 6 277	-R 13 065	-R 10 357	-R 7 182	-R 14 183	R 32 667	R 39 805	R 26 494
Income	-R 2 510	R 10 228	R 1 217	R 10 905	R 11 550	R 2 420	R 54 956	R 15 627	-R 4 003	R 16 315
Expenses	R 6 163	R 6 533	R 6 926	R 7 342	R 7 782	R 8 249	R 8 746	R 9 271	R 9 827	R 10 416
PBIT	-R 8 673	-R 5 759	-R 11 986	-R 9 502	-R 6 589	-R 13 012	R 32 027	R 39 024	R 25 975	R 32 393
Interest	-R 781	-R 518	-R 1 079	-R 855	-R 593	-R 1 171	R 641	R 780	R 519	R 648
Net Cash Flow	-R 9 454	-R 6 277	-R 13 065	-R 10 357	-R 7 182	-R 14 183	R 32 667	R 39 805	R 26 494	R 33 041

Table 30 Scenario 2: Year 1 - Monthly cash flows

2010	Income	Expenses	PBIT	Interest	Net Cash Flow
Jan	-R 27 211	R 500	-R 27 711	-R 2 494	-R 30 206
Feb	R 16 222	R 503	R 15 719	R 314	R 16 034
Mar	R 13 528	R 505	R 13 023	R 260	R 13 284
Apr	-R 27 605	R 507	-R 28 113	-R 2 530	-R 30 643
May	R 8 187	R 510	R 7 677	R 154	R 7 831
Jun	R 9 472	R 512	R 8 960	R 179	R 9 139
Jul	-R 15 483	R 515	-R 15 998	-R 1 440	-R 17 438
Aug	R 8 306	R 517	R 7 788	R 156	R 7 944
Sep	R 9 609	R 520	R 9 089	R 182	R 9 271
Oct	-R 15 708	R 522	-R 16 230	-R 1 461	-R 17 691
Nov	R 8 426	R 525	R 7 901	R 158	R 8 059
Dec	R 9 748	R 527	R 9 221	R 184	R 9 405
Total	**-R 2 510**	**R 6 163**	**-R 8 673**	**-R 781**	**-R 9 454**

Table 31 Farmer1's yearly cash flow with winter seasons included and using the cross genotype

Cash Flow	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Starting Cash flow	R 0	R 28 816	R 60 532	R 108 126	R 203 165	R 243 678	R 304 974	R 352 702	R 411 854	R 554 187
Income	R 34 415	R 37 063	R 52 399	R 98 398	R 43 517	R 63 566	R 49 558	R 60 346	R 141 293	R 58 189
Expenses	R 6 163	R 6 533	R 6 926	R 7 342	R 7 782	R 8 249	R 8 746	R 9 271	R 9 827	R 10 416
PBIT	R 28 251	R 59 345	R 106 006	R 199 181	R 238 900	R 298 994	R 345 787	R 403 778	R 543 320	R 601 960
Interest	R 565	R 1 187	R 2 120	R 3 984	R 4 778	R 5 980	R 6 916	R 8 076	R 10 866	R 12 039
Net Cash Flow	R 28 816	R 60 532	R 108 126	R 203 165	R 243 678	R 304 974	R 352 702	R 411 854	R 554 187	R 613 999

Table 32 Varying selling prices based on commercial remuneration standards and dressing %

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Selling Price/kg chicken meat	**R 15.00**	-R 26 612	-R 56 435	-R 76 142	-R 65 664	-R 105 212	-R 131 148	-R 179 637	-R 225 969	-R 212 547	-R 276 667
	R 16.24	-R 12 685	-R 26 527	-R 27 968	R 6 288	-R 9 173	-R 7 843	-R 25 541	-R 37 179	R 18 536	-R 1 238
	R 18.00	R 6 628	R 14 437	R 36 296	R 98 236	R 108 592	R 137 517	R 150 522	R 172 453	R 267 659	R 284 223
	R 20.00	R 27 648	R 58 106	R 104 345	R 197 642	R 236 568	R 296 160	R 342 061	R 399 254	R 539 106	R 596 642
	R 22.00	R 48 669	R 101 776	R 172 394	R 297 049	R 364 544	R 454 803	R 533 600	R 626 055	R 810 554	R 909 061
	R 23.58	R 65 275	R 136 275	R 226 153	R 375 581	R 465 644	R 580 131	R 684 916	R 805 228	R 1 024 998	R 1 155 872

8 Conclusions and Recommendations

The aim of this study was to determine whether contract farming is a feasible arrangement for small-scale broiler farmers. Generally, from this study, results showed that small-scale farmers have to overcome a number of limitations in order to produce economically. The first objective was to build a model which could be used to analyse various small-scale farmer scenarios using a typical commercial broiler genotype. Three different broiler production scales were investigated. Scenarios were setup on each scale of production and a "what-if" analysis was performed by varying production parameters such as selling prices, mortality rates and feed prices. The second objective was to collect data on a crossbred genotype and compare economic outcomes if this genotype was used instead of the commercial broiler genotype. Financial performance indicators, such as the net present value and cash flows were used to analyse the feasibility of all the modelled scenarios.

A major limitation was the availability of data on the small-scale broiler farming industry in South Africa. Due to limited published work on the small-scale farming sector, a South African Poultry Association conference was attended where approximately 350 small-scale broiler farmers had gathered from across South Africa. Conference proceedings highlighted the key problems encountered by the farmers. All the farmers were members of the Development Poultry Farmer's Association. Furthermore, unstructured interviews were helpful in gaining a real understanding of what the farmers needs are and helped in obtaining information about their specific detailed operational and managerial problems. The conference also served as a networking base. The farmers on which the case study is based were first met at the conference.

The base model used commercial data that served as a "Best Case" scenario. Results revealed that based on the capital costs used, a 500 bird scale of production is uneconomical and that a farmer would have to receive R25.05/kg for broiler meat in order to break even. The 1500 bird scale of production revealed much better results. Farmers could break even at R17.51/kg meat. The capital investment cost of the 2500 bird scale of production was so high that the farmer would have to sell his broiler meat for R18.54/kg.

Next, the experimental trial data was entered into the model to compare variable costs, fixed costs and cash flows. Results predominantly indicated that a crossbred genotype was not suitable for an intensive production system, but that it would definitely be worthwhile investigating performance traits under less than optimal conditions or in a free-range system. The free-range system offers many benefits which would increase the likelihood of success. Capital costs are lower and the cross genotype is expected to perform better in the free-range production system. It is also expected that under less than optimal conditions the HC will have a poorer performance and will thus make it more comparable to the performance of the KR genotypes. The broiler lines did not perform as well in less than optimal environments, compared to the commercial standards. Farmers obtained a live weight of only 1.5 kg at 35 days compared to the commercial industry that reaches 1.82 kg at 35 days. In less than optimal conditions, the KR might perform similarly to, or even better than, the broiler.

Cash flows were used to analyse the case study. Results showed that if small-scale farmers were able to produce broilers in the winter season, the net cash flow would increase dramatically. Further, the case study investigated the cash flows under various selling prices. A small-scale farmer, farming with crossbred genotypes, should be able to receive R23.58/kg in order for him to make a business cash flow of R 65 275 by the end of year one.

Although outcomes were not entirely positive, a basis for future research has been established. As mentioned, the crossbred genotype should be investigated under a less intensive production system, such as a free-range system. Another important investigation could be to test the impact of alternative feed formulations for each genotype.

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Appendix A

Nutrient Specifications

		Starter		Grower		Finisher	
Age fed	days	0-10		11-24		25-slaughter	
Energy	kcal	3025		3150		3200	
	MJ	12.65		13.20		13.40	
AMINO ACIDS		**Total**	**Digest[1]**	**Total**	**Digest[1]**	**Total**	**Digest[1]**
Lysine	%	1.43	1.27	1.24	1.10	1.09	0.97
Methionine & Cystine	%	1.07	0.94	0.95	0.84	0.86	0.76
Methionine	%	0.51	0.47	0.45	0.42	0.41	0.38
Threonine	%	0.94	0.83	0.83	0.73	0.74	0.65
Valine	%	1.09	0.95	0.96	0.84	0.86	0.75
iso-Leucine	%	0.97	0.85	0.85	0.75	0.76	0.67
Arginine	%	1.45	1.31	1.27	1.14	1.13	1.02
Tryptophan	%	0.24	0.20	0.20	0.18	0.18	0.16
Crude Protein	%	22-25		21-23		19-23	
For optimal portions margin it is recommended that amino acid density be increased up to 5% in all diets							
MINERALS							
Calcium	%	1.05		0.90		0.85	
Available Phosphorus	%	0.50		0.45		0.42	
Magnesium	%	0.05-0.50		0.05-0.50		0.05-0.50	
Sodium	%	0.16-0.23		0.16-0.23		0.16-0.20	
Chloride	%	0.16-0.23		0.16-0.23		0.16-0.23	
Potassium	%	0.40-1.00		0.40-0.90		0.40-0.90	
ADDED TRACE MINERALS PER KG							
Copper	mg	16		16		16	
Iodine	mg	1.25		1.25		1.25	
Iron	mg	40		40		40	
Manganese	mg	120		120		120	
Selenium	mg	0.30		0.30		0.30	
Zinc	mg	100		100		100	
ADDED VITAMINS PER KG		**Wheat based feed**	**Maize based feed**	**Wheat based feed**	**Maize based feed**	**Wheat based feed**	**Maize based feed**
Vitamin A	iu	12000	11000	10000	9000	10000	9000
Vitamin D3	iu	5000	5000	5000	5000	4000	4000
Vitamin E	iu	75	75	50	50	50	50
Vitamin K (Menadione)	mg	3	3	3	3	2	2
Thiamin (B1)	mg	3	3	2	2	2	2
Riboflavin (B2)	mg	8	8	6	6	5	5
Nicotinic Acid	mg	55	60	55	60	35	40
Pantothenic Acid	mg	13	15	13	15	13	15
Pyridoxine (B6)	mg	5	4	4	3	3	2
Biotin	mg	0.20	0.15	0.20	0.10	0.10	0.10
Folic Acid	mg	2.00	2.00	1.75	1.75	1.50	1.50
Vitamin B12	mg	0.016	0.016	0.016	0.016	0.010	0.010
MINIMUM SPECIFICATION							
Choline per kg	mg	1600		1500		1400	
Linoleic Acid	%	1.25		1.20		1.00	

Figure 34 Nutrient specifications for as-hatched broilers grown < 1.9kg live weight (ROSS, 2007)

		Starter		Grower		Finisher	
Age fed	days	0-10		11-24		25-slaughter	
Energy	kcal	3025		3150		3200	
	MJ	12.65		13.20		13.40	
AMINO ACIDS		**Total**	**Digest[1]**	**Total**	**Digest[1]**	**Total**	**Digest[1]**
Lysine	%	1.43	1.27	1.24	1.10	1.09	0.97
Methionine & Cystine	%	1.07	0.94	0.95	0.84	0.86	0.76
Methionine	%	0.51	0.47	0.45	0.42	0.41	0.38
Threonine	%	0.94	0.83	0.83	0.73	0.74	0.65
Valine	%	1.09	0.95	0.96	0.84	0.86	0.75
iso-Leucine	%	0.97	0.85	0.85	0.75	0.76	0.67
Arginine	%	1.45	1.31	1.27	1.14	1.13	1.02
Tryptophan	%	0.24	0.20	0.20	0.18	0.18	0.16
Crude Protein	%	22-25		21-23		19-23	
For optimal portions margin it is recommended that amino acid density be increased up to 5% in all diets							
MINERALS							
Calcium	%	1.05		0.90		0.85	
Available Phosphorus	%	0.50		0.45		0.42	
Magnesium	%	0.05-0.50		0.05-0.50		0.05-0.50	
Sodium	%	0.16-0.23		0.16-0.23		0.16-0.20	
Chloride	%	0.16-0.23		0.16-0.23		0.16-0.23	
Potassium	%	0.40-1.00		0.40-0.90		0.40-0.90	
ADDED TRACE MINERALS PER KG							
Copper	mg	16		16		16	
Iodine	mg	1.25		1.25		1.25	
Iron	mg	40		40		40	
Manganese	mg	120		120		120	
Selenium	mg	0.30		0.30		0.30	
Zinc	mg	100		100		100	
ADDED VITAMINS PER KG		**Wheat based feed**	**Maize based feed**	**Wheat based feed**	**Maize based feed**	**Wheat based feed**	**Maize based feed**
Vitamin A	iu	12000	11000	10000	9000	10000	9000
Vitamin D3	iu	5000	5000	5000	5000	4000	4000
Vitamin E	iu	75	75	50	50	50	50
Vitamin K (Menadione)	mg	3	3	3	3	2	2
Thiamin (B1)	mg	3	3	2	2	2	2
Riboflavin (B2)	mg	8	8	6	6	5	5
Nicotinic Acid	mg	55	60	55	60	35	40
Pantothenic Acid	mg	13	15	13	15	13	15
Pyridoxine (B6)	mg	5	4	4	3	3	2
Biotin	mg	0.20	0.15	0.20	0.10	0.10	0.10
Folic Acid	mg	2.00	2.00	1.75	1.75	1.50	1.50
Vitamin B12	mg	0.016	0.016	0.016	0.016	0.010	0.010
MINIMUM SPECIFICATION							
Choline per kg	mg	1600		1500		1400	
Linoleic Acid	%	1.25		1.20		1.00	

Figure 35 Nutrient specifications for as-hatched broilers grown to 2.0-2.5kg live weight (ROSS, 2007)

Appendix B

Case study: Scenario 1

“As - Is” - Flock Profile

Table 33 Flock profile for scenario 1

Flock Profile	
No. of chicks placed per cycle	1600
Mortality rate	0.05
No. of birds less mortality rate	1520
Plant condemnations	0.02
No. of birds sold per cycle	1489.6
Finish live weight (kg)	1.5
Dressing % (farmer sells on a per bird basis @ R 12.67/kg live weight)	1
No. of kgs sold per cycle (live)	2235
Chick purchase price	3.75
Days to market	35
Cleaning period	25
Cycle period	60
No. of cycles	6.08
Amount of manure sold per cycle (kg)	0.0
Estimated price obtained per kg of manure	0.0

Appendix C

Case study: Scenario 2

Table 34 Flock profile for scenario 2

Flock Profile	
No. of chicks placed per cycle	1600
Mortality rate	0.05
No. of birds less mortality rate	1520
Plant condemnations	0.02
No. of birds sold per cycle	1489.6
Finish live weight (kg)	1.5
Dressing % (farmer sells on a per bird basis @ R 12.67/kg live weight)	1
No. of kgs sold per cycle (live)	2235
Chick purchase price	3.75
Days to market	35
Cleaning period	10
Cycle period	45
No. of cycles	8.11
Amount of manure sold per cycle (kg)	0.0
Estimated price obtained per kg of manure	0.0

Scheduling of feed cost ration payments

Table 35 Scheduling of feed cost ration payments

Date	Cycle Nr	Production Schedule	Feed Cost	Feed Ration
2010/01/01	1	grow	R 5494.50	Starter
2010/01/02	1	grow	0	
2010/01/03	1	grow	0	
2010/01/04	1	grow	0	
2010/01/05	1	grow	0	
2010/01/06	1	grow	0	
2010/01/07	1	grow	0	
2010/01/08	1	grow	0	
2010/01/09	1	grow	0	
2010/01/10	1	grow	0	
2010/01/11	1	grow	0	
2010/01/12	1	grow	0	
2010/01/13	1	grow	0	
2010/01/14	1	grow	0	
2010/01/15	1	grow	R 8093.17	Grower
2010/01/16	1	grow	0	
2010/01/17	1	grow	0	
2010/01/18	1	grow	0	
2010/01/19	1	grow	0	
2010/01/20	1	grow	0	
2010/01/21	1	grow	0	
2010/01/22	1	grow	0	
2010/01/23	1	grow	0	
2010/01/24	1	grow	0	
2010/01/25	1	grow	0	
2010/01/26	1	grow	0	
2010/01/27	1	grow	0	
2010/01/28	1	grow	0	
2010/01/29	1	grow	R 6951.66	Finisher
2010/01/30	1	grow	0	
2010/01/31	1	grow	0	
2010/02/01	1	grow	0	
2010/02/02	1	grow	0	
2010/02/03	1	grow	0	
2010/02/04	1	grow	0	
2010/02/05	1	clean	0	
2010/02/06	1	clean	0	
2010/02/07	1	clean	0	
2010/02/08	1	clean	0	
2010/02/09	1	clean	0	
2010/02/10	1	clean	0	
2010/02/11	1	clean	0	

Table 35 continued.

2010/02/12	1	clean	0	
2010/02/13	1	clean	0	
2010/02/14	1	clean	0	
2010/02/15	2	grow	R 5534.12	Starter
2010/02/16	2	grow	0	
2010/02/17	2	grow	0	
2010/02/18	2	grow	0	
2010/02/19	2	grow	0	
2010/02/20	2	grow	0	
2010/02/21	2	grow	0	
2010/02/22	2	grow	0	
2010/02/23	2	grow	0	
2010/02/24	2	grow	0	
2010/02/25	2	grow	0	
2010/02/26	2	grow	0	
2010/02/27	2	grow	0	
2010/02/28	2	grow	0	

Appendix D

Case study: Scenario 3

Table 36 Flock profile for scenario 3

Flock Profile	
No. of chicks placed per cycle	1600
Mortality rate	0
No. of birds less mortality rate	1600
Plant condemnations	0.02
No. of birds sold per cycle	1568
Finish live weight (kg)	2.02
Dressing % (farmer sells on a per bird basis @ R 12.67/kg live weight)	1
No. of kgs sold per cycle (live)	3168
Chick purchase price	3.75
Days to market	60
Cleaning period	10
Cycle period	70
No. of cycles	5.21
Amount of manure sold per cycle (kg)	0.0
Estimated price obtained per kg of manure	0.0

Table 37 Production schedule: Summary

	Nr of Placements and Slaughters	
Year	**Placement**	**Slaughter**
1	6	5
2	5	5
3	5	5
4	5	6
5	6	5
6	5	5
7	5	5
8	5	5
9	5	6
10	6	5

Table 38 Production schedule: Detail

Years 1 - 5			Years 6 - 10	
Placement	**Slaughter**		**Placement**	**Slaughter**
01-Jan-10	02-Mar-10		06-Mar-15	05-May-15
12-Mar-10	11-May-10		15-May-15	14-Jul-15
21-May-10	20-Jul-10		24-Jul-15	22-Sep-15
30-Jul-10	28-Sep-10		02-Oct-15	01-Dec-15
08-Oct-10	07-Dec-10		11-Dec-15	09-Feb-16
17-Dec-10	15-Feb-11		19-Feb-16	19-Apr-16
25-Feb-11	26-Apr-11		29-Apr-16	28-Jun-16
06-May-11	05-Jul-11		08-Jul-16	06-Sep-16
15-Jul-11	13-Sep-11		16-Sep-16	15-Nov-16
23-Sep-11	22-Nov-11		25-Nov-16	24-Jan-17
02-Dec-11	31-Jan-12		03-Feb-17	04-Apr-17
10-Feb-12	10-Apr-12		14-Apr-17	13-Jun-17
20-Apr-12	19-Jun-12		23-Jun-17	22-Aug-17
29-Jun-12	28-Aug-12		01-Sep-17	31-Oct-17
07-Sep-12	06-Nov-12		10-Nov-17	09-Jan-18
16-Nov-12	15-Jan-13		19-Jan-18	20-Mar-18
25-Jan-13	26-Mar-13		30-Mar-18	29-May-18
05-Apr-13	04-Jun-13		08-Jun-18	07-Aug-18
14-Jun-13	13-Aug-13		17-Aug-18	16-Oct-18
23-Aug-13	22-Oct-13		26-Oct-18	25-Dec-18
01-Nov-13	31-Dec-13		04-Jan-19	05-Mar-19
10-Jan-14	11-Mar-14		15-Mar-19	14-May-19
21-Mar-14	20-May-14		24-May-19	23-Jul-19
30-May-14	29-Jul-14		02-Aug-19	01-Oct-19
08-Aug-14	07-Oct-14		11-Oct-19	10-Dec-19
17-Oct-14	16-Dec-14		20-Dec-19	
26-Dec-14	24-Feb-15			

Appendix E

Case study: Scenario 4

Table 39 Flock profile for scenario 4

Flock Profile	
No. of chicks placed per cycle	1600
Mortality rate	0
No. of birds less mortality rate	1600
Plant condemnations	0.02
No. of birds sold per cycle	1568
Finish live weight (kg)	2.02
Dressing %	0.63
No. of kgs sold per cycle (live)	3168
Chick purchase price	3.75
Days to market	60
Cleaning period	10
Cycle period	70
No. of cycles	5.21
Amount of manure sold per cycle (kg)	0.0
Estimated price obtained per kg of manure	0.0